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THE USE OF RESOURCE UNITS IN TEACHING MATHEMATICS

KENNETH B. HENDERSON
University of Illinois, Urbana, Illinois

"I wish more time were spent telling us *how to do* some of the things we are always told we ought to be doing." So spoke a teacher to whom I was once talking. The lady had a point. There probably are as many perplexing problems involved in how to teach as in deciding what ought to be taught.

It is toward the "how-to-do" that the resource unit is pointed. Yet the "what-to-do" is involved, for the contention of this article is that mathematics teachers ought to be building and using resource units in their teaching.

WHAT A RESOURCE UNIT IS

Perhaps it would be well to begin by defining a resource unit and citing some of its salient characteristics. Alberty[1] states that a resource unit "—is a systematic and comprehensive survey, analysis and organization of the possible resources (e.g., problems, issues, activities, bibliographies, etc.) which a teacher might utilize in planning, developing, and evaluating a learning unit."

In mathematics, a resource unit may have as its subject some significant aspect of living such as taxation, sharing our economic risks, managing your money, or the geometry of shape, size, and position. Or the subject may be one more related to the sequential courses in mathematics such as graphs and equations, numbers, functions, and so on. The topic, problem, or aspect of living should be broad enough to warrant more than a few days study of it, yet sufficiently de-

[1] Harold Alberty, *Reorganizing the High School Curriculum*, p. 250. New York: The Macmillan Company, 1947.

limited to be seen as a whole by pupils of the level of maturity for which it is written.

The resource unit looks at its subject broadly and cuts across subject matter lines. Thus a resource unit on insurance or sharing economic risks will consider such relevant aspects as how our forefathers shared risks, the kinds of risks which are shared, the purposes of various life insurance plans, how rates are set, and whether the government should extend or curtail its insurance activities. There is a place for much quantitative thinking, e.g., the collection of quantitative data and their interpretation, the working of problems which involve decimals, percentage, ratio, etc. There is also provision for non-quantitative thinking when questions involving "oughts" are considered. The idea is to offer a vista of the forest without spending all the time studying a few individual trees.

Yet a resource unit is not a teaching-learning unit. It is different from such units as Managing Your Money, Buying Insurance, and Using Consumer Credit, three units (which, incidentally every teacher of general mathematics should have) of the Consumer Education Study.[2] These units are essentially texts which are placed in the hands of the students. A resource unit on the other hand is for the teacher's use. Students rarely, if ever, will see it.

A resource unit, as the name suggests, is a source of help to the teacher. It is a storehouse of information, and a reservoir of ideas; the pantry to which a teacher can go for suggestions on what to teach and what learning experiences are appropriate.

Most resource units are organized in terms of the following points:

a. *Orientation.* The significance of the unit and its relation to the purposes of education are explained. Also, an explanation of some aspects of the subject is given for the benefit of a teacher who is not too well versed on the subject of the unit.

b. *The objectives of the unit.* These are often stated rather specifically as understandings or in terms of desired changes in students' behavior.

c. *Suggested activities.* These are the heart of the resource unit. There are things for students to do and read to get the unit started, to develop the understandings, and to conclude and summarize the work on the unit. This section contains one-half or more of the contents of the whole resource unit.

d. *Evaluation.* In this section suggestions are made for evaluating the achievement of the students and the contribution of the unit. Diagnostic and achievement tests, anecdotal records, questionnaires,

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[2] These may be secured for thirty-five cents each by addressing the Consumer Education Study, 1201 Sixteenth St., N.W., Washington 6, D. C.

essays, reading records, and other data-gathering techniques are suggested.

e. *Bibliographies.* Two bibliographies are commonly given. One is for the teacher should he want to know more about the unit and its various ramifications. Films and film strips, free and low cost materials, and other visual and auditory aids are included. The other bibliography consists of readings which are appropriate for students. Both bibliographies are usually annotated.

Using Resource Units

One great contribution of a resource unit is in affording the teacher a fighting chance of meeting the varying needs, abilities and interests of the students in his class. With the average teacher it is frequently a case of the spirit's being willing, but the ideas scarce. To stimulate equally students at both ends of the curve of variability, demands a person with remarkable originality, resourcefulness, and experience. So many students; so little time!

The teachers who worked on the resource unit on Insurance at the Curriculum Workshop at the University of Illinois last summer had the problems of teachers in mind. Hence, activities were suggested which would appeal to students whose special abilities are meeting and talking with people, art work, speaking, collecting factual data, abstract thinking, writing, and others. These teachers selected activities and included problems suitable for all levels of mathematical proficiency. From the wealth of workable ideas, a teacher should be able to find enough educative activities to keep the brilliant student working to capacity and provide the slow student with the feeling of success that psychiatrists insist we all need.

Should a teacher use a unit plan of teaching, the resource unit can help in planning the scope and development of the unit, in writing guide sheets, and in building self-tests and final tests. But if a teacher feels most secure in day-to-day assignments, these can be individualized in some measure by taking advantage of the pooled experience of those who wrote a resource unit relevant to the subject being studied. The flexibility of resource units is one of their chief advantages.

A third use of resource units is in facilitating student-teacher planning. The values of this activity have been explained and documented elsewhere and need only to be mentioned in passing. Planning with students how a unit, problem or subject will be studied: 1. Provides training in making group decisions, the heart of the democratic method, 2. Develops self-direction, 3. Enhances motivation, and 4. Clarifies the purposes of the particular subject studied as well as those of education in general.

With so much to be said for planning with students, why do so few

teachers do it? Probably one reason is that they feel insecure as to the outcome of such planning. After all, it is a venture in the dark. The path can seldom be laid out in advance. As one teacher reported, "I planned with a class a unit on formulas. Several of the boys in the class wanted to study the formulas used in aviation and navigation. I knew only three such formulas. As a result I didn't show up too well in their eyes or my own. I am a little reluctant to try that procedure again."

Unfortunately, conventional curricula for training mathematics teachers are short on such subjects as taxation, insurance, installment buying, wise buying of goods and services, measurement, the nature of proof, and others. Many mathematics teachers know much less about these subjects than they do about simultaneous equations, logarithms and the binomial theorem for example. Hence, from one point of view, the smart thing in teaching the former topics is to stick closely to the textbook and entertain no suggestions from the class concerning their interests. In such a scheme there is little opportunity for giving students experience in planning and group thinking.

Here is where the resource unit enters the picture. Having been developed by several teachers who have considered the subject broadly, it is a source of security to the teacher. From it he can suggest alternatives for the students' consideration when they say, for example, "What can we study about taxation?" From it he can make suggestions on sources of data and things to measure when a group of students studying a unit on conservation say "We want to study how fast our soil is washing away and why the water table is dropping so fast." By referring to the bibliography he has an answer to the student who says, "I get a kick out of graphing equations. Where can I read some more about various equations and their graphs?" By referring to the bibliography, he can fortify himself on certain aspects of the unit which are new or which he has forgotten.

A resource unit is a horn of plenty. With one of these available, a teacher can feel more secure in a student-teacher planning situation. Adequate resources are marvelous confidence builders.

Prospects for Securing Resource Units

There are more resource units in such areas as the Social Studies, English, and Science than in Mathematics. But a few resource units in mathematics do exist. In the appendix of *Mathematics in General Education* is a resource unit on normal variability. This unit considers the subject, Am I Normal?, a subject every survey discloses as a problem of great concern to adolescents. The resource unit on Insurance has been previously mentioned. *The Aviation Education Source Book,* while not a true resource unit, closely resembles one. A

check of the Education Index for the past fifteen years failed to uncover other resource units on mathematics.

So far, publishing companies have not considered it profitable to publish resource units. One reason is that resource units are too new on the educational horizon. The result of this policy is that many resource units which are developed in mimeographed form do not get the attention they deserve. This was the fate of several of the resource units developed during the Eight-Year Study. When the time comes that teachers begin to inquire about resource units from the representatives of book companies who visit them, the book companies will begin to turn these out.

So far, resource units have been developed chiefly by groups of teachers in workshops. Several of these were held during the Eight-Year Study. They are continuing to be held on university campuses and by school systems.

The Philadelphia Schools hold a workshop each summer. The Board of Education of Nazareth, Pennsylvania has this year provided its staff of teachers five days for curriculum development. While the development of resource units has not been a reported purpose of such school workshops, the time is available should teachers decide building resource units would be a desirable project.

We need resource units on many topics in mathematics. We should have resource units on taxation, consumer problems, managing money, sharing economic risks, measurement, man's invention of numbers, argumentation and proof, the language of algebra, informal geometry, functions, how man speeds up his calculating, to name a few. The need is great; the pay-off for the reasons given above would be even greater.

PROFESSOR SUTTON AT CASE

Dr. Richard M. Sutton of Haverford College has been engaged to teach in the General Electric Science Fellowship program for high school physics teachers at Case Institute of Technology, Cleveland, Ohio, June 27 to August 5. The appointment is announced by Dean Elmer Hutchisson of Case. Dr. Sutton has been named Visiting Professor of Physics at Case for the 1949 summer term.

The General Electric Fellowship Program in which Dr. Sutton will teach offers 50 all-expense fellowships to teachers of high school physics in Ohio, Michigan, Indiana, Illinois, Kentucky, West Virginia, Wisconsin and Western Pennsylvania. The program of study offered by the Case faculty and the scientific staff of General Electric provides a review of fundamental concepts of physics and of recent developments in physical sciences. Visits to the Lamp Development Laboratory and other laboratories of the General Electric Company in Cleveland are included in the program. Requests for fellowship application blanks are being handled by Dean Hutchisson at Case.

PROGRESSING TOWARD NOVEMBER

Excellent suggestions have been received from members for the 1949 convention on November 25 and 26 at Edgewater Beach Hotel, Chicago. These are always welcomed by Mr. Milton D. Oestreicher, local arrangements coordinator, or myself.

The convention schedule will be slightly modified this year at the request of members in order that eight sectional meetings will not be in session at the same time. Four of these will be held in the morning following a one-hour general meeting, and four in the afternoon following a second one-hour general session. Overlapping of subject matter areas will be avoided in so far as possible, thus giving a greater number of persons the opportunity of attending several sections. No changes are being made in the Saturday morning schedule.

Dr. Paul Aebersold, Chief, Isotopes Division, Atomic Energy Commission, will be a speaker on the Friday morning general meeting. Dr. William A. Sanford, College of Education, University of Illinois and Director of the Secondary School Curriculum Study in Illinois, will talk on the Saturday morning general session. Other speakers will be announced later.

Sectional and Group Chairmen are planning very worthwhile programs. We look forward to having you with us at the 1949 convention.

CHARLOTTE L. GRANT, *President*

AWARDS FOR RESEARCH PI LAMBDA THETA

Pi Lambda Theta announces two awards of $400 each, to be granted on or before August 15, 1949, for significant research studies in education.

An unpublished study may be submitted on any aspect of the professional problems and contributions of women, *either in education or in some other field.* Among others, studies of women's status, professional training, responsibilities and contributions to education and to society, both in this country and abroad, will be acceptable.

No study granted an award shall become the property of Pi Lambda Theta, nor shall Pi Lambda Theta in any way restrict the subsequent publication of a study for which an award is granted, except that Pi Lambda Theta shall have the privilege of inserting an introductory statement in the printed form of any study for which an award is made.

A study may be submitted by any individual, whether or not engaged at present in educational work, or by any chapter or group of members of Pi Lambda Theta.

Three copies of the final report of the completed research study shall be submitted to the Committee on Studies and Awards by June 1, 1949. Information concerning the awards and the form in which the final report shall be prepared will be furnished upon request. All inquiries should be addressed to the chairman of the Committee on Studies and Awards.

ALICE H. HAYDEN, University of Washington, Seattle 5, Washington, *Chairman*

LABORATORY WORK IS ESSENTIAL

TRAVER C. SUTTON
Cass Technical High School, Detroit, Michigan

We are convinced that effective science requires plenty of real laboratory working time—in fact more school time should be devoted to true science laboratory work. If we actually wish to teach the sciences this provision of time for laboratory work is of paramount importance. Let us not forget that the remarkable progress of the sciences in America is due in large measure to the amount of laboratory work that has been done in our secondary schools. Conclusions of any other character must be based upon invalid inferences or upon the results of carelessly accepted general statements by those not familiar with the real demands of science teaching.

It is true that the atomic age has forced us, as science and mathematics teachers, to evaluate and re-evaluate our capabilities and our deficiencies. We must realize as never before the necessity of presenting our science subjects so that every secondary school student is given the opportunity to receive the type of science and mathematics instruction that will enable him to lead a more effective life. The demands of the age gives emphasis to the importance of honest participation, on the part of the student, in good basic training in science and mathematics.

The present day program of science training, necessitated by the complexities of the atomic age, is a success because the average science teacher, in college or in high school work, during the past twenty years, has insisted upon doing a fairly good job of teaching the basic science courses—and maintaining laboratory work of such a character as to establish in the minds of students the workability of the principles studied. These science teachers have not had much time for student self-expression, interest function, and motivation and activation in the fields of diluted subject matter—they have been too busy teaching the sciences needed in this very scientific atomic age.

There has been developed among many persons, not trained in science work, during these past twenty years, a dangerous tendency to insist that we neglect the teaching of the fundamentals of science—and to attempt the teaching of the applications of principles without teaching the principles themselves. Also there has been a definite tendency, in some school systems, to neglect science laboratory work—not because laboratory work is not accepted as being of great and real value, but because it costs money and requires the services of really skilled and well-trained instructors to direct such work.

Under certain educational influences the subjects of chemistry, physics, etc., have been combined into "something" called a composite or combination science course. Such so-called science courses are interesting—and they do possess a limited practical value, but they have failed, in the opinion of many experienced teachers, as a true method to be used in teaching the sciences in the secondary schools.

This age demands that the schools teach the fundamentals as well as their useful applications. If this background of fundamentals and fact is not provided, the teaching of applications and the scientific attitude is a farce. It is a sure thing that students cannot apply with understanding in their own lives, facts and principles which have not been learned.

An excellent illustration of application without knowledge is found in the following story: An old and faithful railroad employee had completed forty-five years of service and was ready for his pension and deserved retirement. A testimonial dinner was given in his honor—and all of the important men of the company were present. They gave long and good sounding speeches of praise for the faithful worker. The employee was presented with a very expensive watch and also a substantial sum of money as tokens of appreciation for his long years of service.

Near the end of the ceremony the toastmaster asked "Old John" if he would like to say a few words. John started his talk by saying that he had been hired by the railroad some forty-five years ago—and during his first day of work he had been given a hammer and told to "tap the wheels" of the incoming passenger trains. He stated with pride that he had been tapping wheels for forty-five years—and felt that he had done a faithful and excellent job of wheel tapping—and now, after all these years, he would like to know "why under heaven the railroad wanted to have the wheels of each incoming passenger train tapped?"

This is a new and strange world in which we are living—and it has created many unusual needs—needs which must be satisfied. While the secondary school science instructor is not usually engaged in the fields of scientific research—he knows that the most important demands are located in the fields of research. He has the job of preparing one group of students for the ordinary demands of industry—and he must prepare another group for college and university entrance. Many of this second group will do research work.

The past twenty years has brought about many important changes in the nature and significance of the objectivity of high school science work. Research has increased the importance of science—and science teaching costs have been increased wherever a really productive sci-

ence program has been maintained. Today there is intensive research into transportation, into radio and all of its related fields, into general communications, into aeronautics, into nursing, into nutrition, into explosives, etc. New kinds of research—atomic research—these are providing new approaches to old problems. Quoting from the booklet *Operation Atomic Vision*, National Association of Secondary School Principals, 1948, we learn that "A new science of metallurgy is beginning to emerge, and a variety of new metals and other materials will soon be available. The greatly increased production of radioactive isotopes will enable basic research to attain goals never before achieved and, in some cases, never before contemplated. This will have extremely important results in medicine, food production, production of goods, and health."

Science continues to develop and improve methods to be used in defensive as well as in destructive offensive warfare. It is also constantly developing methods for preserving and protecting human lives. It has constantly built and bettered machines—in fact it has helped in the creating and developing of an untold number of usable things.

The propulsive influence of science on the family, on education, and on government is self-evident. Because of this influence the need for proper scientific education at the high school age becomes very important. This education job belongs to individuals who are scientists—not to educational theorists. Also those students who will never become scientists must be made familiar with the basic sciences, with true scientific method, and with the significance of scientific research, if they are to be appreciative and intelligent citizens. Lyman Spitzer, Jr., chairman of the University (Yale) Council's Committee on the Division of the Sciences, states that "The present trend toward incorporating scientific training into a broadly cultural curriculum should be continued. This will require an expansion of the facilities for science teaching."

Industry and government have many problems to solve—and in nearly every case it has been the scientist, with his factual knowledge, plus his applications of scientific methods, who has provided the workable solutions. Quoting from the 1948, November issue of the *Yale Alumni Magazine*, we find that "the demand for scientists outside the universities has broadened beyond all expectation. The previous few decades saw a rising number of chemists and geologists in private industry and now physicists are in equal demand from both industrial and governmental laboratories." War always demands that the efforts of the enemy not only be met but be surpassed. Industry makes the same kind of demands in reference to trade competition. These pressure demands have caused the scientists to bring together

and organize scientific knowledge so that wars may be quickly won—and also that we may win in the fields of competitive industry.

These achievement contributions are being made by trained scientists. The scientist is able to make his contribution because he has realization of the importance of fundamental knowledge based on experiment. He accepts the challenge of adding to the frontiers of knowledge.

During times of peace and times of war industry has become so complex that the average person must study with diligence and attention in order to understand its most basic requirements. When a new industrial activity develops—or during a war time emergency—the demand for men and women trained in the sciences becomes pressing and insistent. Many good and apparently intelligent people seriously and sincerely believe that shortage of qualified scientists can be filled by teaching a large number of selected persons a few basic scientific rules and procedures. Honest science teachers have been looking for these few basic scientific rules and procedures for many long years—and these teachers are pretty sure they do not exist. There are few "short cuts" in ordinary teaching—and practically none in science teaching.

The public high schools are many times requested, within a very limited time, to perform miracles—for example, they are expected to turn out a finished product in the form of competent, scientific, technically trained persons. Honest educators in the field of technical accomplishment know that this cannot be done overnight.

It takes time and plenty of time in the form of individual laboratory and student shop experience to prepare such a finished product. It requires skill and time to teach the needed mathematics—to make the student comprehend and understand the needed scientific fundamentals—and it takes more time to direct laboratory and shop work so that a true understanding of application is acquired.

It is true that we have certain educational philosophies, added to a mass production school program, plus the idea of no individual science laboratory work, plus a diluted type of mathematics, existing in some areas, that is "squelching and stifling" our high school students. There are many educators, not familiar with the real contributions and requirements of science teaching, who possess a willingness to eliminate the traditional laboratory work of the sciences before research has demonstrated, in any way, better method or methods of doing the job. Please remember that the laboratory sciences have been doing a pretty good job of producing qualified science people for many years.

The extent to which many educators are willing to neglect true research—and accept with enthusiasm pseudo-findings may well be

termed "blind fumbling." Have we reached a point where we are willing to lavish money and training only upon social school activities —and produce conditions that invite the unfit to become more unfit and encourage the fit to stop the struggle and remain static? We wonder!

Recently we had dinner with the manager and owner of a small but good manufacturing plant. This man employs a relatively large number of young men who must possess good basic science training. Our subject of conversation was naturally about high school science teaching, and the manner in which industry judged the results of such science teaching. Allow me to pass on to you his observations. Here they are: "You high school teachers give to us plenty of high school graduates who can talk all of the answers but they cannot actually use their hands and heads in getting the job done. There is a definite need for the practical application of the technical and scientific information to the job. We have checked with our workers and found that those having plenty of shop and individual laboratory experience are the ones who really deliver the goods."

One day not so long ago we had a very interesting conversation with a very wise old teacher who said to me, "I am a very devoted baseball fan. I have carefully studied baseball strategy and know all of the fine points of the grand old American game. When Charlie Gehringer was in his prime I was able from the ***grandstand*** to tell him about his good plays, and I felt well qualified to give him some good pointers about how to avoid making bad plays. For many years I have watched and studied the manner in which baseball players demonstrate their baseball ability. I know baseball. In fact I could write a perfect examination on baseball—rules and playing and management." Then this old and wise teacher leaned back in his chair and continued, "In spite of my baseball knowledge and my years of watching baseball demonstrations no big league baseball manager has as yet offered me a contract to become a playing member of his team. When I consider the vast sum of baseball information I have accumulated, and the knowledge of the game I have acquired plus the technique I have developed in watching baseball demonstrations—and while I have never actually played any baseball—I am a little disappointed to find big league baseball managers so lacking in appreciation and true judgment."

Our conversation continued with, "I wish I were as sure of any one thing as the majority of our reformers of science teaching are of everything,"—and then after a pause, "What were you saying about substituting science demonstrations for individual laboratory work?"

In a technical high school, the training in the shops and laboratories is only the application of the science and mathematics learned

in the classrooms. Through science and mathematics, the applications learned in the school shops and laboratories take on their true meaning and form the link between the school and the industrial life of the community. Technical secondary school instructors have always had faith in the ideal of well taught fundamentals. They have known that a thorough knowledge of the basic sciences was necessary if an individual was to be considered competent in the technical fields.

Because they possessed the facts, these science and mathematics teachers—when War II arrived—at once understood the problem—as they now understand the immediate problems of industry—the need being for more training in the actual laboratory sciences and in mathematics.

This may interest you. A few days ago the principal of a large technical high school received a phone call from one of the high ranking officials of an organization employing thousands of men. This man insisted in being informed as to why more of the graduates of this particular technical school were not being received by his company. This official stated that if more of these graduates were not channelled to his company he was going to see the superintendent of schools or the board of education—because he needed men who knew their basic sciences and understood mathematics. We wonder how many high schools offering diluted courses in science and mathematics have been threatened in this complimentary manner!

We have always assumed that the real justification for teaching a particular science was to be found in the uses made of the science. The method selected for the teaching should be solely in the terms of the use objectives to which it is intended to insure. With this thought in mind, and still not convinced that the non-laboratory method might not be of value as a substitute for some of the individual laboratory work we made it a point to consult with a man who has taught in secondary school science for at least thirty years. In order to start the argument we remarked that students having the opportunity of observing demonstration science experiments, carried out under competent teachers, seem to be able to obtain a very good understanding of the subject. We pointed out that when mastery tests were given these students were able to pass the tests with very high grades. In fact they did as well on the tests as did those students who gained the information through the use of the traditional laboratory methods. My colleague agreed with the statement made. Then he observed, "I have used the demonstration method and given mastery tests, and I have found that my students obtained excellent marks. However when these boys who have observed and apparently thoroughly understood the science demonstrations are placed on jobs outside the school they fail. While on the other hand the youngsters who

did not receive as high grades on the mastery tests but who had had the opportunity to handle and to work with actual apparatus in the laboratory were able to succeed on the same type of job.

How many of the non-laboratory advocates would be willing to have an individual, who has never been in a plane but who completed a theory course in airplane operation—and who has received excellent classroom demonstrations in the methods to be used by an air pilot—and who has written an excellent examination in the subject, be the pilot of a plane in which the non-laboratory advocate would be a passenger during his first flight?

Would dropping the emphasis on the individual laboratory method, which when properly directed seems to be the best means of developing reasoning powers of our high school pupils, aid our boys and girls to use their heads for something more than storehouses for the accumulation of facts? There is a feeling that the attempts to get away from tried and proved fundamentals are merely alibis of a teaching generation which may have betrayed its students by not insisting upon a firm grounding in those essentials which can be gained only through student participating experiences. The feeling has often been expressed that many students are being made remarkable "smatterers of science," and that some of the reforms in teaching are leaving them far less truly educated than their parents and grandparents are, or were.

The technical schools have always been ready to accept new ideas provided they offer a better way of doing the job. But to substitute untried ideas and plans in the place of methods known through experience to be workable and usable seems silly. Science teachers are pretty sure that the well taught basic sciences make a worthy and real contribution to an effective defense of our national ideals.

Is there an attempt being made to direct science education by those not interested in having America continue its leadership in the world? We cannot accept a theoretical educational phylosophy that seeks to destroy the very type of science education that has made America strong. Are there decisions being made as to how and what we should teach in science by individuals—and groups of individuals—whose interest is centered in nations outside of America? As we watch the apparent deliberate destruction and disintegration of our science program—and observe the type of thing being substituted—we are forced to wonder why the transition is taking place.

Most science teachers like the individual laboratory teaching method. They are committed to it—and know that it works. They feel that it is the best method to be used in teaching the sciences. They have watched the "observational type of science teaching" and other methods in operation—and have seen the lack of good results.

Teachers know that there is plenty of room for improvement in the individual laboratory method—and that it is the job of good science teachers to make these needed improvements. If we work at improvement effectively we will spread the benefits of our system and gain the firm confidence of the parents of our students and educators in it.

CONFERENCE ON TEACHING MATHEMATICS, GRADES 1–12

SPONSORED BY THE DEPARTMENT OF MATHEMATICS AND THE SCHOOL OF EDUCATION, THE UNIVERSITY OF WISCONSIN, JULY 18–22

Theme: The learning of mathematics is a continuous growth from earliest number experiences to graduation.

Planning the curriculum for grades 1–12, basic concepts, mathematics in general education, providing for the accelerated, and applications are points for special emphasis on the various days of the Conference. There are a number of study groups planned to meet once a day each of the five days. The program also includes showing of films, a demonstration class, lectures by representatives of business and industry, a visit to the University computing laboratory, and panel discussions conducted by Wisconsin teachers. The organization of the program is in two parts, one for elementary teachers and the other for secondary school teachers. However all social events and a number of general sessions will be shared by the two groups.

Among leaders of the Conference are: Mr. Paul W. Eberman, University of Chicago; Professor Harold Fawcett, Ohio State University; Miss Lenore John, University of Chicago; Miss Mary A. Potter, Mathematics supervisor, Racine; Professor W. D. Reeve, Columbia University; Professor W. B. Storm, Northern Illinois State Teachers College; and Professor F. L. Wren, George Peabody College for teachers.

Topics for the study groups include: The Mathematical Content of the Secondary School, Problem Solving in Arithmetic, Junior High School Mathematics, Laboratory in Construction of Classroom Models, What Are Meanings in Mathematics, Understandings that Should be Developed in Arithmetic, Audio-Visual Materials and Methods in Mathematics, Surveying and Use of Instruments.

For a complete program and additional information write to Professor J. R Mayor, North Hall, The University of Wisconsin, Madison 6, Wis.

BOOKLET ON ATOMIC ENERGY REPRINTED

The 32-page illustrated Little Science Series booklet, "The World Within the Atom," has been reprinted for a third time.

The booklet, prepared by Dr. L. W. Chubb, Director Emeritus of the Westinghouse Research Laboratories, tells how scientists explored the atom and learned to release its energy. It describes the work of Thomson, Rutherford, Bohr, Curie, and other scientists, and gives important background information on nuclear physics and on the development of the atomic bomb.

The booklet will have additional value when used in conjunction with the lithographed wall charts on nuclear physics which were recently released.

Copies of the booklet for classroom distribution can be obtained, free of charge, from the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avence, Box 1017, Pittsburgh 30, Pa.

CURRENT APPROACHES IN THE TEACHING OF SCIENCE

MILES MAX MILLER
Kearny Junior-Senior High School, San Diego
AND
KATHARINE DRESDEN
Stanford University, Stanford, California

There are many important topics in science—not only in chemistry and physics, but biology and general science as well—that cannot be effectively taught except through use of current materials. These materials include periodicals, films, filmstrips, pamphlets, advertising materials or whatever else provides information on current scientific discoveries and applications. As reference materials, these are often more attractive and interesting to the student than the usual standard references. Students who use them, moreover, are more apt to become aware of the wide significance of scientific knowledge; the relation of past achievements to present and future; and the effects of scientific progress on cultural and social problems.

Such outcomes, of course, will not happen merely by accident. They come only as the result of carefully planned classroom experiences. An important question is this: If an appreciable portion of the class time is devoted to the use of current materials, to what extent are these desired outcomes achieved? And to what extent, if at all, are they achieved at the expense of more formal subject-matter learning?

It was to answer these, and other questions, that a study was carried on in the physics and chemistry classes of the Kearny Junior-Senior High School in San Diego, as one of the projects of the California Council on Improvement of Instruction.[1] Over the three-year period of the study, one day a week was devoted to topics for which current materials were the basic materials for study. Special attention, for the first few weeks, was given to assignment procedures, methods of using the materials, and the development of classroom procedures that stressed pupil initiative and leadership, and effective classroom discussions.

As an example of a typical procedure, we may consider how the topic "Radioactivity" was treated. This is a part of the basic information in a chemistry course, yet the texts cannot keep pace with developments. The chairman for the panel, appointed in advance by the instructor, outlined the purpose and scope of the discussion and

[1] Reginald Bell and Lucien Kinney. *Better Teaching Through the Use of Current Materials.* Stanford University Press, 1947.

appointed five topic-chairmen. These, in turn, selected their own study groups.

The major source of information on "Radioactivity" is current materials. In the time preceding this panel a great deal had been read in current materials on this topic, so all pupils had some information. Everyone helped to gather material, intentionally or accidentally. All files in the classroom which contained past articles from *Life*, "tear-sheets" from *Fortune*, and other "fugitive" materials were open to the pupils. A partial list of articles pertinent to Radioactivity used by these pupils gives emphasis to the fact that there is a great deal of reliable information available for school-room use. This list is not complete, but some that pupils were known to use follow:

"Atom Bomb Island," *Life*, 105–109, March 25, 1946.
"Atom Bomb Effects," *Life*, 91–94, March 11, 1946.
"Geiger Counter," *Life*, 103–109, April 1, 1946.
"Peacetime Use of Atomic Energy," *Life*, 97, December 2, 1946.
"Power," *Life*, 98–99, December 2, 1946.
"Tracers," *Life*, 100–101, December 2, 1946.
"Atomic Energy Control," *Life*, 102–103, December 2, 1946.
"Genetics," *Life*, 83–93, March 17, 1947.
"The Weirdest Danger in the World," *Popular Science*, 96–90, October, 1946.
"Beyond the Atomic Bomb," *Fortune*, (Supplement) September, 1945.
"The Atomic Age Begins," *Time*, August 20, 1945.
"Background for the Atomic Age," a portfolio of articles from *Time*, *Life*, and *Fortune*.
Soloman, A. K., "The Physics of the Bomb," *Fortune*, 113–175, May, 1946.
Davis, Harry, "We Enter a New Era—the Atomic Age," *New York Times Magazine*, 5, August 12, 1945.
O'Neill, John, "They're 'Shattering' Atoms Now," *Science Digest*, 41, April, 1946.
Gallagher, Dr. B., "Prometheus Rampant," *Vital Speeches*, 141, December 15, 1946.
"Defense Planned Against Radioactive Poison Gas," *Science News Letter*, 121, August 25, 1945.
"Made to Order," *Science News Letter*, 103, August 18, 1945.
"Rapid Assembling," *Science News Letter*, 102, August 18, 1945.
Davis, Helen, "Laws of Matter Up-to-Date," *Science News Letter*, 223, October 6, 1945.
"New Atomic Particles Being Investigated," *Science News Letter*, 323, November 24, 1946.
"Birth of Atom Splitting," *Science News Letter*, 167, March 16, 1946.
"Atomic Power Leads," *Science News Letter*, 389, December 22, 1945.
"Science Review of 1946," *Science News Letter*, 389, December 22, 1946.

The library assembled source materials. These materials were recent reference books, periodicals, pamphlets, and abstracts from scientific records. All preparation for the panel, sharing of information, and organizing of topic-committees were done outside of class. On the appointed day the discussion was carried out in a well organized fashion. The chairman and members of the panel took places at the front of the room. The other pupils, visitors, and instructors

were in the class seats. The chairman made some introductory remarks, giving the topic, purpose of the discussion, and briefly outlined the procedure for presentation. The chairman then introduced the first topic-chairman. He made his contribution and called on his committee members. The other topics were covered in the same manner. Every question or contribution by anyone in the room on material covered was recognized at the time by the general chairman. Each topic-chairman summarized his topic, and the general chairman summarized the panel in conclusion.

The following day a brief check was made of results of the panel by the chairman giving a brief oral quiz over the topic. Every pupil made a contribution and participated in some manner at least once during the panel discussion. Each pupil seemed to have a working knowledge of "Radioactivity."

It has been pointed out that it was the purpose of the study to explore the effectiveness of various procedures and to suggest practices that merit further experimentation.

When something is added to a full curriculum, something else must be dropped. There is always more than can be done in any class. Utilization of current materials undoubtedly has its value, but to determine whether they are justifiable in the science classes it was necessary to determine whether these pupils made the expected progress in regular subject outcomes, and what special values resulted beyond those commonly expected.

Questions pertinent to this evaluation, and suggestions as to the types of data needed for this purpose are as follows:

a. Subject-matter learning:

What progress did the student make in the recognized subject-matter outcomes during the study? How did this compare with progress made in regular classes?

b. Special outcomes:

What is the student's progress in knowledge of current problems and events?

c. Stimulation of learning:

What was the effect on interest in the subject and activities of the classroom?

Briefly, the results may be summarized as follows:

1. Comparisons with control classes at La Jolla (1946–47) and Sweetwater (1947–48), using the Cooperative Physics Tests and Chemistry Tests, were as follows:

	1946–47 Scaled Score		1947–48 Scaled Score
Kearny	54.5	Kearny	54.0
La Jolla	55.0	Sweetwater	55.5

It is interesting to note that in both cases the achievement of Kearny students is slightly, but not statistically, below that of the control classes.

It is possible that what slight differences existed may be attributed to differences in intelligence between the classes. The average I.Q. of the Sweetwater students was 109.2; La Jolla, 113.5; and that of the Kearny students, 105.0.

In every case the average of the scaled scores of the Kearny students has been practically the same as the average scaled scores of those classes conducted in the conventional manner. It may be said that regularly accepted curricula achievement by chemistry and physics students is not diminished by devoting one-fifth or more of the time to a study of current materials.

2. Knowledge of current affairs; comparisons with control classes. Since the subject-matter achievement of the Kearny students was practically equivalent to that of the control classes, a superiority in knowledge of current affairs by the science classes may be construed as representing an advantage attributable to the use of current materials. Three sets of test data from the *Time* Current Affairs Tests, may be compared as to median scores:

	May 1947		January 1948		May 1948
Kearny	41.8	Kearny	41.6	Kearny	40.4
La Jolla	37.0	Sweetwater	33.1	Sweetwater	31.3

The students in the experimental classes were superior in each case.

3. Stimulation of learning. It was the subjective reaction of teacher and pupils that the use of current materials provided greater interest and significance to the classroom activities. A variety of evidence was collected that substantiates this point of view, including:

Spot checks on percentage of participation;

Reactions of administrators, supervisors, consultants, parents, and other interested visitors;

Results of a pupil questionnaire;

Results of a parent questionnaire.

An analysis and summary of this evidence clearly indicated that the procedure utilizing current materials provided interest and promoted pupil participation and leadership.[2]

But how permanent is this interest in current problems and current materials? It is important that the adult citizen be informed, and literate with respect to sources of information. If we utilize cur-

[2] *The California Council on Improvement of Instruction, January-1946-June 1947*. Stanford University, July 1947. (mimeographed).

rent periodicals as basic materials for the classroom, are we not likely to develop the same aversion toward them that is typical of the student attitude toward the textbook?

To acquire information on this point, a questionnaire was mailed in March 1948 to the 83 graduates of the previous two years who had been in the chemistry and physics classes. Replies were received from 61. The questionnaire was designed to secure information on the following questions:

1. What periodicals were read, and how extensively? How did this compare with their high school practices?
2. What topics of current interest were read most frequently?
3. What is their present appraisal of the procedures in the high school science classes?

Of the replies received, 34 were from graduates attending college classes, and 27 from graduates not attending college. Tabulations were prepared separately for the two groups.

The periodicals listed as being read, and the estimate of comparative time spent on them, was as follows:

Summary of Responses to Questionnaire on Post-high-school Reading Habits of Pupils in Project Classes

Periodical	Hours Per Week Spent by Ex-Pupils in Reading Periodicals			Compared to Time Spent When in High School		
	Pupils now: In College	Pupils now: Not in College	Total	Pupils now: In College	Pupils now: Not in College	Total
Daily Newspaper	139	136.5	275.5	+	−	0
Time	46	57.5	103.5	+	+	+
Life	30	65	95	0	0	0
Reader's Digest	5	25	30	−	+	+
Collier's		27	27		−	−
Women's Magazines	4.4	18	22.4	0	+	+
Popular Science		17.5	17.5		+	+
Newsweek	5	4	9	0	+	+
Sat. Eve. Post		9	9		−	−
National Geographic		5	5		+	+
Others	17		17	0		0
TOTAL	242.4	364.5	606.9		+ = More	
N	34	27	61		− = Less	
M	7.1	13.5	9.9		0 = Same	

It appears that as a group former pupils were spending 9.9 hours per week on current materials, but those attending college averaged only 7.1 hours, while non-college graduates averaged 13.4 hours. This is probably attributable to the assigned reading which partially con-

trols the habits of college students. It is interesting to note also that *Reader's Digest*, *Collier's*, *Popular Science*, *Saturday Evening Post*, and women's magazines are more consistently read by the non-college groups. With a few exceptions, the tendency was to read each periodical more than, or about the same as in high school.

Turning to the question of what topics are of interest, it is to be recalled that the questionnaire was sent out in March, 1948. The topics, in general, reflect the news items of the period. The number reporting each topic was as follows:

Universal Military Training		54
Russia		52
Marshall Plan		43
Palestine Question		43
Tax on Oleomargarine		17
UNESCO		5
Sports		1
Science		98
Palomar Telescope	29	
Supersonic Flight	26	
Rocket Testing	25	
Television	14	
Medical Science	4	

How do the former students, as they look back, appraise the effectiveness of the procedures used in the science classes? Did they feel that they could have profited from more rigorous study of the text? Or from more pupil discussion? While the response from such a pupil evaluation is not final, it is vaulable evidence on pupil attitudes, and an indication of the extent to which they understood and accepted the purposes of the activity.

The number of pupils suggesting more emphasis, less emphasis, or the same emphasis for each of the listed activities was as follows:

Activity	*More*	*Same*	*Less*
Pupil demonstrations	48	12	2
Talks by specialists	47	9	0
Current magazines	46	14	0
Oral recitations	37	19	1
Educational films	37	23	0
Pupil-led discussions	35	9	4
Field trips	33	16	6
Teacher demonstration	24	30	2
Pictures and charts	23	30	3
Textbooks	13	35	7
Written lessons	11	33	13
Teacher-led discussions	10	33	11

The general attitude, so far as it can be identified, appears to be that there should be *more* pupil demonstrations, visiting specialists, current periodicals, recitations, films, and discussions. The teacher-led activities appeared to be at about the approved level. It is not clear what (unless written lessons) was to be reduced to provide this

increase in the former activities. It is to be recalled that these are recommendations made by former students for the benefit of their successors, and also that at least one-fifth of the time of the class had been devoted to current materials.

To summarize, the experiences in the chemistry and physics classes in the Kearny Junior-Senior High School justify the following conclusions:

1. In the recognized subject-matter outcomes, as measured by standard tests, the students were somewhat above national norms, and were about equal to comparable classes taught without emphasis on current materials.

2. In information on current problems in general, and current science in particular, the experimental classes were superior.

3. The procedures utilizing current materials provide greater pupil and teacher interest, and promoted pupil participation and leadership.

4. The interest developed in current periodicals, current affairs, and current science tends to persist after the pupils leave high school.

FROM BLUEPRINT TO ACTION

It is but a few months since Mr. Carnahan wrote to us about the BLUEPRINT OF A DREAM, but planning has proceeded rapidly since that time. What is it all about?—The Board of Directors of CASMT has been making plans for a fitting celebration of the 50th anniversary of our Association. They very correctly argue that the best tribute we could pay to the work of the founders would be a special publication—a book which would do justice to the half century of activity in the field of science and mathematics teaching. They realized that we move along in the changes of our day, and only too seldom recognize those changes and the part which we play in them.

The book is intended to be a brief history of CASMT as well as of science and mathematics teaching during the past half century. Fifty years is a long time, but into this period were crowded more vital concepts and changes than men had packed into centuries preceding it. The plan is no longer a "blueprint," it is work in progress, and it is a BIG job. The book will be around 200 pages in length, it will be divided into four more or less major chapters, which will represent four important panoramic views including our Association and the teaching of the sciences and mathematics. The plan presents the place of our Journal in that period, the men and women of CASMT from 1900 to 1950, a chapter each for teaching of biological sciences, physical sciences and mathematics. Changes involving teacher training will

no doubt also receive some consideration in the various chapters. Two authors will collaborate on work for each section except on the one in mathematics. And here is the title of the book:

A HALF CENTURY OF TEACHING OF SCIENCE AND MATHEMATICS

It is now with pride that we introduce to you the members of CASMT who were willing to shoulder the additional responsibility There is first the editorial committee: Mrs. Jerome Isenbarger, chairman, Chicago; Walter H. Carnahan, editor-in-chief, Boston; Miss Mary Potter, Racine, Wisconsin; Walter G. Gingery, Indianapolis. Secondly we introduce the writers: The chapter on personal history of the Association, our Historian, Edwin W. Schreiber, Macomb, Illinois; affairs of the Journal, our Editor, Glen W. Warner, Lakeville, Indiana; Biological Sciences, John C. Mayfield, Chicago, and Jerome Isenbarger, Chicago; Physical Sciences, Ira C. Davis, Madison, Wisconsin, and Allen Meyer, Detroit, Michigan; Mathematics, Ernst R. Breslich, Chicago.

On January 22 the Editorial Committee met with the authors in Chicago and agreed on a detailed plan of procedure in the work.

In this labor of love the ideals of a great teacher group will stand silhouetted against one of the most significant half centuries in the history of the teaching profession, and of mankind as a whole.

THE PUBLICITY COMMITTEE

OUTDOOR AND CAMPING EDUCATION SUMMER SCHOOL

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SCIENCE INSTRUCTION AND THE LABORATORY*

Kenneth E. Anderson
The University of Kansas, Lawrence, Kansas

During the school year 1946–47, fifty-six Minnesota high schools, selected by random means from among the 483 high schools in the state, consented to take part in a comprehensive study of science instruction. The role of the laboratory in student achievement was one of the areas studied. The study of laboratory instructional practices was limited to the two sciences biology and chemistry, and was concerned with two problems: (1) to determine those factors which make for better student achievement, and (2) to secure an accurate description of certain specific laboratory procedures and practices.

Achievement Factors

Three factors in the area of laboratory work were studied to determine their influence on pupil achievement as measured by the final examinations used in the study. These examinations were constructed to measure: factual understandings, principles of science, the understanding and use of the scientific method, and scientific attitudes. By means of random selection, representative classes were obtained in which: (1) a laboratory manual was used and in which a laboratory manual was not used, (2) laboratory instruction preceded class discussion and in which laboratory instruction followed class discussion, and (3) the number of laboratory hours of instruction per student per year fell in the upper one-fourth as shown in the state distribution, and in which the number of laboratory hours of instruction per student per year fell in the lower one-fourth as shown in the state distribution.

By using the technique of analysis of variance and covariance it was possible to hold constant the factors of pupil intelligence and pretest knowledge. The results of these analyses showed that on the average, pupils achieved significantly more on the final examination in biology when the number of laboratory hours received per student per year was in the upper one-fourth as shown by the state distribution rather than in the lower one-fourth, and also that the following factors were not significant in pupil achievement in biology: the time of laboratory instruction and the use or non-use of laboratory manuals.

The results of the analyses in chemistry showed that on the average, pupils achieved significantly more on the final examination in chemistry when: (1) the number of laboratory hours received per

* This article is but a small part of the study: "The Relative Achievements of the Objectives of Secondary School Science in a Representative Sampling of Fifty-Six Minnesota Schools," unpublished Doctoral Dissertation, University of Minnesota, 1949. Copies of the complete summary may be had by writing the author at the University of Kansas.

student per year in the upper one-fourth as shown in the state distribution rather than in the lower one-fourth, and (2) the pupil was in a class that used a laboratory manual rather than in a class that did not use a laboratory manual. The time of laboratory instruction was found to be non-significant in pupil achievement in chemistry.

Procedures and Practices

Each of the teachers participating in the study submitted a schedule describing his instructional practices and procedures. The following statements regarding laboratory instruction and supplies were obtained by an analysis of the schedule:

1. The percentage of teachers using laboratory manuals in their instruction was 55 per cent in biology and 91 per cent in chemistry.
2. The percentage of teachers whose laboratory instruction preceded, accompanied, or followed class discussion was 5 per cent, 65 per cent, and 30 per cent respectively in biology. In chemistry the percentages were 13 per cent, 51 per cent, and 36 per cent respectively.
3. The percentage of teachers who used the demonstration method almost exclusively, some, or little, was 16 per cent, 72 per cent, and 12 per cent respectively in biology. The percentages in chemistry were 9 per cent, 71 per cent, and 20 per cent respectively.
4. Instructors rated their supplies as excellent, fair, or poor. The percentages in biology were 7 per cent, 70 per cent, and 23 per cent respectively. The percentages in chemistry were 49 per cent, 46 per cent, and 5 per cent respectively.

Further analysis of the schedules revealed that one-fourth of the students in biology received 59.5 hours or more of laboratory instruction per year, while one-fourth of the students in biology received 12.1 hours or less of laboratory instruction per year. The median number of laboratory hours received per year was 33.25. Teachers recommended a median number of 37.19 hours as a minimum for the year's instruction in biology. In chemistry, one-fourth of the students received 73.55 hours or more of laboratory instruction per year, while one-fourth of the students received 34.5 hours or less of laboratory instruction per year. The median number of laboratory hours received per year was 59.5. Teachers recommended a median number of 60.75 hours as a minimum for the year's instruction in chemistry.

The following laboratory procedures were listed by the teachers in the frequencies of mention shown:

Follow a laboratory manual or workbook	65
Pupils obtain information through activities planned by the teacher	43
Controlled experiments	42

Verification of things read in the text, newspapers, magazines, or advertisements	37
Problems and projects such as building demonstration models, mounts, making ink, etc.	32
Pupils given things to do before discussion in class	20
Follow the experiments outlined in the text	19

Possession of the following pieces or supplies of laboratory equipment was indicated by the percentage of teachers shown:

Good laboratory tables	82
Demonstration desk	86
Storage cases	93
Running water	100
Two or three sinks	81
Tables equipped with gas	80
Equipped with 110 or 120 volt A.C. current	84
Work bench	31
Demonstration desk equipped with running water, gas, and electricity	81

Teachers indicated what they considered to be the chief functions of the science laboratory. The following are the first ten of the twenty-nine listed, according to frequency of mention:

To develop skill in the use of laboratory apparatus	21
To understand and use the scientific method	17
To develop student interest in science	15
To develop the habit of careful observation	15
To test theories and ideas learned in class	14
To develop an understanding of science principles and the ability to apply principles	13
To bridge the gap between theory and practice	11
To learn by doing	11
To prove scientific laws and truths	6
To develop scientific attitudes	6

Only in a few instances was the laboratory separated from the classroom. The median number of square feet in the laboratory or combination laboratory-classroom was 750.

Summary

Teachers of science, as represented by the teachers in this study were in the main dependent on laboratory manuals for laboratory instruction in science, although they used a variety of other procedures. More teachers of chemistry were dependent on a laboratory manual

than were teachers of biology. Most of the laboratory instruction accompanied class work and most teachers used the demonstration method as a supplement to individual or group laboratory exercises. Chemistry teachers rated their laboratory supplies higher in terms of quality and amount than did biology teachers. Most of the teachers indicated that they possessed standard laboratory equipment of the heavy type and sources of gas and electricity. All of the teachers indicated that their science laboratories were supplied with running water, but this was the only equipment or supply found to be universal. Although teachers indicated that the development of skill in the use of apparatus was one of the chief functions of the science laboratory, it was encouraging to note that careful observation, understanding and use of the scientific method, development of scientific attitudes, and understanding of principles, were functions of the science laboratory listed among the first ten.

It was shown that the number of laboratory hours received per year was an important factor in achievement as measured by the final examination. Teachers of science and administrators should take cognizance of this fact in making provisions for science instruction. The median number of hours of laboratory instruction received per year was slightly less than the median number of hours recommended by the teachers in both biology and chemistry. The picture of laboratory instruction in these two sciences as presented by the study suggests that improvement of laboratory work will increase pupil achievement.

A SPECIAL COURSE IN SCIENCE AT HARVARD

President James B. Conant together with Professors Duane Roller of Wabash College and Fletcher G. Watson of the Harvard Graduate School of Education will offer a special course in the Harvard Summer School of 1949 under the title "Science in General Education at the College Level."

This course will provide an opportunity for teachers of physics, chemistry, and other physical sciences in liberal arts colleges, junior colleges, and teachers' colleges to discuss one of their major common problems. Professor Earl J. McGrath of the University of Chicago (formerly Dean of the College of Arts and Sciences, State University of Iowa) will summarize the variety of courses in science in general education being developed at colleges throughout the United States.

INDIANA UNIVERSITY WORKSHOP

Indiana University will hold its second annual Workshop for Mathematics Teachers June 20 to July 2. Graduate credit will be given for those who desire it. There will be exhibits, lectures, group discussions, and analysis of problems brought in by members. Programs will be available about May 1. If you wish a program, please write Philip Peak, University School, Bloomington, Indiana.

ASTRONOMY IN THE JUNIOR HIGH SCHOOL CURRICULUM

Harry E. Crull
Butler University, Indianapolis, Indiana

Astronomy has frequently been somewhat a neglected area on the junior high school level. The reasons for this fact are directly related to the quantitative standing of astronomy in the average college curriculum. Relatively few of our colleges offer complete astronomical training and many have no courses at all. This is a result not so much of a lack of interest but of the physical remoteness of the astronomical bodies coupled with an unfortunate combination of expensive equipment and negligible commercial potentialities for monetary return which has characterized astronomical research in modern times. In an era when a few circles and sighting tubes were the astronomers tools and lucrative horoscopes were his stock in trade, interest and information (or misinformation) were more widespread. Today with observatories costing millions, and mathematical and physical knowledge necessary to the astronomer surpassing all previous experience with no measurable commercial return visible, we have acquired a frame of mind which encourages the belief that astronomy has become an area of esoteric knowledge for the elect.

It is my thesis today that this unencouraging point of view need not govern our approach to the problem of a unit in astronomy on the junior high school level (nor on any other level, for that matter). While many larger and wealthier high schools may be fortunate in their equipment and faculty training, there is no reason why even the smallest school can not present an intelligent and profitable study of the oldest and most majestic science.

It seems there are two broad governing principles to be remembered in presenting the subject at this level. We must first keep uppermost in our minds the fact that we are endeavoring to present one facet of a complete and integrated science study. Much of the effectiveness of the unit will be lost if we fail to keep before us always the goal of relating this unit with the others in science. Astronomy does not stand alone or isolated from the other aspects of science; indeed it is sometimes difficult to delineate a boundary between astronomy and physics or mathematics. Actually the discoveries and wonders of astronomy are simply ingeneous projections of earthly knowledge and experiences. The distance of the moon, planets, sun or most remote nebulae is firmly founded upon the work of the surveyor with his transit and tape, the temperature and constitution of the stars on that of the physical chemist in this earthly laboratory and the orbits of the comets on the labors of the dynamical physicists. This beautiful

and essential interrelation of effort and knowledge should be preserved and strengthened in our presentation of the unit.

The second principle we are bound to observe is that of appropriateness of level of presentation. One's first reaction to the available mass of highly technical and finely developed astronomical data is one of confusion. A sense of frustration with the task of presenting this material to junior high school pupils is to be avoided carefully and in no way should we transmit to the student any subconscious conviction of the teacher on the apparent difficulty of the subject. Actually no fear need be felt. Boy scout and girl scout leaders, summer camp counselors and a host of others have demonstrated for years that the essentials of astronomy constitute a profitable and fascinating area for the junior high group. If the teacher's college background did not include a formal course in astronomy, this need not be an insurmountable barrier to a highly profitable and instructive experience for both him and the class. A healthy confidence in his ability coupled with sufficient caution and a willingness to dig out the necessary facts which are readily available should carry any normally intelligent teacher successfully through this unit.

May I now present what I hope will be useful and helpful suggestions for the implementation of the somewhat idealistic outline of our objective. First may I suggest that in the unit as in all others the student profits immensely by actual accomplishment on his own part. Do not permit him to learn the constellations without drawing a star chart for your locality and season, or constructing a star finder of some sort. Armand Spitz's "Pinpoint Planetarium" is a fine aid in this area. Nor should he read of the earth's rotation without spending a half an hour sighting a rising or setting star against the school chimney. Changing noon-day altitude of the sun can be vividly demonstrated by stakes driven in the school yard at the end of the noon day shadow of the flag pole, or thumbtacks in the class room floor similarly placed. This demonstration is most effective over a short period near the equinoxes but very striking if a comparison of December and June altitudes can be made.

A telescope is of great help and is by no means as difficult to obtain as would seem at first glance. There are thousands of men and women throughout this country who have made instruments of fine optical quality. Fortunately they are all possessed of a missionary spirit coupled with an understandable pride in their achievement which make them definite assets to your program. It is also possible that some of the more mechanically minded pupils can be interested in the construction of a simple reflecting telescope so clearly described in such works as *Amateur Telescope Making* (Scientific American Publishing Co.) Any such project can result in a permanent and valuable

addition to your teaching aids. Astonishingly good reflectors are available commercially at reasonable prices, but buy one only on a return basis if you are inexperienced. Do not trust advertisers claims. If a high ceilinged stairwell is available do not overlook the possibility of a Foucault pendulum, twenty or more feet are necessary for the suspension, and the higher the better. Use a heavy bob and a strong straight wire to hang it.

If funds are available an almost unlimited supply of lantern slides are obtainable on all astronomical subjects. Among the most complete selections in this country are those of the Mount Wilson Observatory Pasadena, California, Lick Observatory Mt. Hamilton, California, and the University of Chicago Press in Chicago, Illinois. The last named prepares a collection of one hundred representative slides which will serve as a nucleus for later additions.

However, it is probable that the limitations of the budget precludes any such outlay as a large collection of slides represents. This need not prove an insurmountable difficulty if full use is made of the facilities of your state or city visual aids division. Frequently fine and helpful service in the area of astronomy is immediately forthcoming from this source. Motion pictures from the University of Michigan Observatories showing the solar prominences and their development are in most state visual aids bureaus.

Should we follow successfully through this effort the rewards are great. Avocational interest can be awakened, budding astronomers started on their careers and school projects successfully completed. In no other scientific field are the potentialities greater, nor the results more evident.

THE QUIZ SECTION

Julius Sumner Miller

Michigan College of Mining & Technology, Sault Ste. Marie, Michigan

1. Three equal spheres are placed on a smooth horizontal plane and are kept together by a string wrapped around them in the plane of their centers. Another identical sphere is placed on top of these. Find the tension in the string.
2. Three equal hemispheres rest with their plane faces upon a rough horizontal plane and in contact with each other. A sphere of the same material is placed atop the three. What is the least coefficient of friction for sliding to just impend?
3. A slender rod lies on the interior of a rough vertical hoop. Find the position of equilibrium.
4. A slender rod is suspended by a string attached to its ends and slung over a smooth peg. Find the equilibrium position(s).
5. The spheres of #1 above are placed in a rough hemispherical bowl. Find the condition for motion of the spheres to impend.

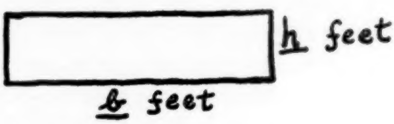
DIMENSIONAL ANALYSIS

APPLIED TO ELEMENTARY MATHEMATICS

BERNARD E. LEVENTHAL
Bay Ridge High School, Brooklyn, N. Y.

What is Dimensional Analysis? Many interesting relationships in mathematics can be discovered by just analyzing the dimensional units of the variables involved. *The basic assumption in dimensional analysis is that both sides of any equation consists of terms of the same unit.* For example, let us consider the perimeter of a rectangle, $p=2b+2h$ where p, b and h are in feet. Translating this equation into the realm of dimensions we have feet = feet + feet. If we were told that this formula was $p=2b+2bh$ or feet = feet + feet^2, we would have a meaningless sum of linear feet and square feet, just as absurd as feet + seconds. However, it is conceivable that some linear constant, k feet, is one of the terms in our formula such as:

$$p=2b+2h+k$$



By noting the dependence of the perimeter upon the other variables in conjunction with the diagram we can show that $k=o$. Let $b=o$ and $h=o$. Then, $p=o$ from the diagram. Thus $o=o+o+k$ or $k=o$. Illustrations of the dimensional method for the derivations of the Binomial Theorem and the Pythagorean Theorem follow:

The Binomial Theorem: The proof which follows is quite general but we will examine the specific case of $(x+y)^3$. Let $x+y$ represent the side of a cube whose volume, $V=(x+y)^3$ we desire to obtain. Since $V=(x+y)^3$ depends solely on the values of x and y we may write this symbolically as $V=f(x, y)$. $V=(x+y)^3=(\text{feet}+\text{feet})^3=\text{feet}^3$. Using the basic assumption that all the terms in our result are of the same dimensional units, we obtain

$$V=(x+y)^3=rx^3+sx^2y+txy^2+uy^3+v \tag{1}$$

where the coefficients are constants. Each term is in cubic dimensions, i.e. $xy^2=\text{feet}\cdot\text{feet}^2=\text{feet}^3$. By the method of undetermined coefficients we can find the respective values of the constants by substituting values for x and y in equation (1)

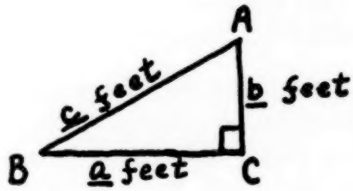
If $x=o$, $y=o$, then $v=o$
If $x=o$, $y\neq o$, then $y^3=uy^3$ or $u=1$
If $x\neq o$, $y=o$, then $x^3=rx^3$ or $r=1$
If $x=1$, $y=1$, then $s+t=6$
If $x=1$, $y=2$, then $s+2t=9$

and by "elimination" we have $s=3$, $t=3$. On substituting the respective values of the constants in (1) we obtain the Binomial Theorem for $(x+y)^3$.

$$(x+y)^3=x^3+3x^2y+3xy^2+y^3.$$

The Pythagorean Theorem:

We observe that once a and b of a right triangle are fixed in length then c is determined. This dependence of c on a and b is represented as $c=f\ (a,\ b)$. Assuming that the relationship is linear, let us write $c=ra+sb+t$. If $a=o$ and $b=o$ then $c=o$ from the diagram. Therefore, $o=o+o+t$ or $t=o$. Similarly if a shrinks to o or $a=o$ then $c=b>o$. Therefore, $b=o+sb$ or $s=1$. If $b=o$, then $c=a>o$ or $a=ra+o$ or $r=1$.



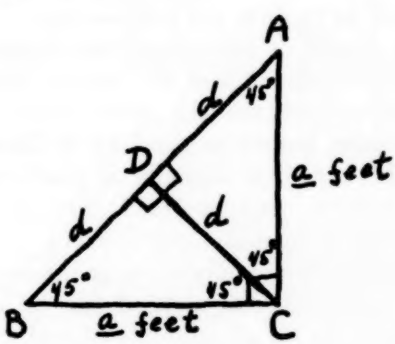
Therefore, $c=a+b$. Since in a triangle $c<a+b$, our assumption of a linear relationship was incorrect and we will therefore investigate the next dimension, feet^2. Thus $c^2=ra^2+sab+tb^2+u$ where both sides of the equation contain terms with square units. Using the same substitutions as in the linear case we obtain (2) $c^2=a^2+sab+b^2$.

Let us refer to a specific right isosceles triangle ABC where $a=b$ (feet) and the angle bisector $CD=d$ (feet). By isosceles triangles, $BD=DA=DC=d$. If we apply equation (2) on the right triangles ABC and BCD we obtain

(3) $4d^2=a^2+sa^2+a^2$

and

(4) $a^2=d^2+sd^2+d^2$.



Solving these two equations simultaneously we have $a=d\sqrt{2}$ and substituting in either equation (3) or (4) we find $s=o$.

From equation (2) we have the resulting Pythagorean Theorem $c^2=a^2+b^2$.

As Application in Physics. In physics, the same method applies. For example, if any weight is dropped from rest, the distance s it travels depends on the constant acceleration of gravity g and the time t it is permitted to fall.

Thus $s=f\,(g,\,t)$. The dimensions of the units follow:

$$s=\text{feet},\quad g=\frac{\text{feet}}{\text{sec.}^2},\quad t=\text{sec.}$$

Combining these units we have $\text{feet}=\dfrac{\text{feet}}{\text{sec.}^2}\cdot\text{sec.}^2$, so that both sides of the equation are dimensionally correct. Thus, $s=mgt^2+n$, where m and n are constants.

When $t=o$, $s=o$, or $n=o$.

$\therefore$ (5) $s=mgt^2$.

We can differentiate and find $ds/dt=2mgt$ and $d^2s/dt^2=2mg$.

But $d^2s/dt^2=g$, the acceleration (defined as the instantaneous rate of change of the velocity, ds/dt, with respect to t).

Therefore $g=2mg$ or $2m=1$ and $m=\frac{1}{2}$. Substituting in (5) we have $s=\frac{1}{2}gt^2$, resulting in the well-known formula in elementary physics. In most formulas, the constant m, as in equation (5) can be found by a physical experiment. In the above problem, if we dropped an object and measured the distance and time, we would be able to compute an approximate value of m. In mathematics, our experiment consists of taking special values of the variables in order to arrive at the proper constants.

Relationships abound in various branches of mathematics which can be derived by the dimensional method. We can rely on this procedure to lead us along the path of discovery and use the standard proofs to confirm our conclusions.

It should be mentioned that **formulas can be "checked"** by the dimensional method by noting whether both sides of the given equation contain the same units. The generalized Pythagorean Theorem, known as the Law of Cosines, $c^2=a^2+b^2-2ab\cos C$, can be checked dimensionally as $\text{feet}^2=\text{feet}^2+\text{feet}^2-\text{feet}\cdot\text{feet}\cdot\text{feet}/\text{feet}$. Each term resolves itself into an area unit and, therefore, the formula is dimensionally correct.

Dimensional analysis, as an interesting checking device and powerful developmental method can be advantageously included in the curriculum for all students of mathematics.

Science has pulled us out of many difficulties in the past—and has given us the means of getting ourselves into worse ones.

—Farrington Daniels

SEVEN INGREDIENTS OF A LIFE OF SERVICE

An analysis of the character traits which enabled one man to benefit millions of people in all parts of the world—even to you and me.

JOHN Y. BEATY
Wee Thistlebrae Farm, Crystal Lake, Illinois

When a man introduces over six hundred new varieties of useful food plants and flowers; when only a few of those form the basis of an industry which is still returning millions of dollars a year twenty-three years after his death; when that man's introductions have proved useful on several continents; when all of that work was stimulated by an insatiable desire to serve all mankind—the rest of us can benefit by studying the principles on which that life of service was based.

Luther Burbank is the man whose accomplishments I have briefed. He benefited more people than any other man I have known.

It was my rare privilege to live and work with Luther Burbank for several years, beginning in 1911. During that experience he impressed me with seven principles of purposeful living which I am sure were responsible for his success.

The seven principles, stated briefly, are as follows:

1. There is *no practical limit* to the service one person may render to his fellow men.
2. There is one type of service for which each one is naturally fitted.
3. When we *know* what we wish to accomplish, the rest is easy.
4. *Enthusiasm* is a necessary ingredient of success.
5. Unlimited *patience* is the price of perfection.
6. Every necessary activity is justified by its usefulness.
7. Anything that is useless or below standard should be promptly discarded.

THERE IS NO LIMIT TO THE AMOUNT OF SERVICE ONE MAY RENDER

If Luther Burbank had thought that each man has a limit to the number of accomplishments for which he may be responsible, we would not have the Shasta daisy, the Burbank plum, an improved race of gladiolas, huge dahlias, cherries in March, walnuts worth $1.00 per nut, and many, many more useful plants. Fortunately, he believed, as a young man, that his accomplishments would be limited only by his own vision, energy, and enthusiasm.

At the end of his life, he had visions of still more useful plants that

might be developed by the techniques he had found so responsive. His service, therefore, was terminated only by the departure of all energy from his body.

He frequently said to me: "Beaty, there is no limit to the amount of useful work one man can do. If one ever thinks he sees a limit, it is because he is lazy, has no vision, or has completely lost his normal enthusiasm. A man without enthusiasm might just as well be dead. He'll simply be a burden to others as long as he lives."

When we are sure there is no practical limit to accomplishment, we will plan more boldly; we will develop techniques with confidence; we will surprise our friends with the great number of things we get done. We will certainly undertake more tasks and more will be successfully completed.

With this principle as the background for his work, Luther Burbank had not less than 3,000 experiments underway all the time. He had about 30,000 new varieties of plums on test each year for several years. He tested scores of plants from all corners of the earth. He combined species which scientists said could not be combined. He developed walnut trees which grew six times faster than varieties previously known.

In short, he did things which others said could not be done—because he didn't *know* those things were impossible.

Each of Us Is a Specialist If We But Recognize Our Ability

My experience with university students makes me think that deciding on a life's work is one of the most difficult problems we have. It commonly takes students two or three years after entering college to decide what line of work they will select as a career. Most of them are lucky (or unusually wise) if they are sure of their career when they graduate.

Fortunately for him (and for us) Luther Burbank knew what he intended to do as a life's work when he was just a child. As a baby, he played with living plants instead of man-made toys. He became a gardener when he was just a boy. Before he was twenty-one he decided he would spend the energy of his life-time in seeking new and useful plants.

His first introduction was the Burbank potato which, today, is grown on thousands of acres in our northwestern states. It was grown from seed he found in his garden as a youth. He recognized his opportunity for service as a plant improver at an early age and he determined to follow the line of work for which he was fitted—and to pursue it with vigor as long as he lived. There was never the slightest doubt in his mind as to his ability to succeed as a plant improver.

When We Know What We Wish to Accomplish the Rest Is Easy

Never did Luther Burbank undertake a task without knowing precisely what he wished to accomplish. He didn't plant seeds just to see what would grow from them. He planted seeds to get a specific type of plant. He made crosses to combine the characters of two plants and to develop new characters which he had clearly in mind. There was an important purpose (often most daring) in every step of his work.

He believed that a larger and sweeter prune would be more useful to mankind. He knew what size, what type, what percentage of sugar he wanted in that prune.

"When I *knew* what I wanted, the rest was easy," he told me. The new prune which was "so easy" to produce was named "Sugar prune."

He wanted another type of prune that would be easy to dry. He *knew* the exact features he wanted in that prune and "the rest was easy." He named that new prune "Standard."

He *knew* he wanted a large daisy with pure white petals. The result was the "Shasta daisy."

He *knew* he wanted a large plum that could be grown in most any climate and that would ship well across our continent. When he found it, a Department of Agriculture official named it the "Burbank plum." It grows in several countries on thousands of acres today.

Enthusiasm Is a Necessary Ingredient of Success

Luther Burbank was an ardent believer in the ability of Luther Burbank. Every new accomplishment was "the thrill of a lifetime." It was a task he knew he could do. He maintained a wholesome enthusiasm to the age of seventy-seven when his physical work on earth was completed.

He was born on a farm near Lancaster, Mass., March 7, 1849. That is why I feel 1949, the centenary of his birth, is a time when I should share with others what I learned by living with him.

Whenever he found a new plant which he had planned—usually years before—he enthused over it as though it was the only thing in life he had ever desired. A new plum aroused his enthusiasm as much as a new heir has aroused the enthusiasm of a proud father.

This enthusiasm was contagious—it was good salesmanship. How could he expect others to believe in his accomplishment—and pay money for it—if he didn't recognize its permanent value and tell of its superiority?

His enthusiasm was a priceless character trait. It not only helped him sell his new products; it made him extremely careful in avoiding

the introduction of a product that didn't deserve enthusiasm unlimited.

Enthusiasm was one of the most important ingredients of his success.

Unlimited Patience Is the Price of Perfection

Bringing into being a worthy product is such a personal thrill that only a strong character can resist the temptation to introduce an inferior variety. Long before the Shasta daisy was introduced, Luther Burbank had daisies larger than any before known. But the petals were not as white as the flower he *knew* he wanted. So he patiently sought a source of increased whiteness. He found it in a wild daisy growing in Japan—a weed.

He crossed this variety with the hybrids he already had and patiently waited until a new variety eventually appeared which had blossoms six inches across with pure white petals.

In many cases, he worked for years, discarding thousands and thousands of new varieties which my lack of patience would have caused me to introduce.

Unlimited patience was the price of success for Luther Burbank. He had both: The patience and the success.

There Are Degrees of Usefulness

One day, he showed me several new varieties of peaches. All appeared to be useful so far as I could see. The fruits were large, the color was attractive, and the flavor was pleasing.

"Surely," I said, "you will introduce all of these new peaches."

"No," he replied. "None of them can thrive in a cold climate. I am working for varieties which can be grown in the northern part of our country. These are all good, but they are not good enough. There are degrees of usefulness, you know.

"I'm afraid, Beaty, that most of us are tempted to be satisfied with most anything that can be classified 'good,' instead of working only for what can be classified 'better.' I am working for plants which will be better than what we have."

He continued his work with peaches until he had a variety which grew successfully in Canada. It classified "better" than any variety we then had.

Certainly it is important to recognize that there are degrees of usefulness—and to set our mark for those accomplishments which classify as "better."

We Must Have the Nerve to Discard What Is Below Standard Or Useless

When I walked with Mr. Burbank through his plum orchard, I saw

literally hundreds of new varieties of plums. Almost every one was large, colorful, and juicy. As far as I could see, there were many there better than varieties being grown in commercial orchards.

Mr. Burbank, however, saw something in most of them which was below standard. On each of those he tied a manila string—his "killing string." That meant the new variety was to be discarded.

In explanation, he said: "If we don't discard what is below standard, we waste time and energy and delay progress. We accomplish more if we stop all unproductive work and apply our time, our energy, and our ability to work which will yield something better than we now have. We actually accomplish more by doing less."

I soon learned that there are many things which most of us do each day which waste precious time. We read unimportant items in a newspaper. We follow habit in our work and go through many motions not necessary to the final result we seek. We have a secretary answer the phone, get the caller's name, and then hand the phone to us—while we stop work and listen to what she is saying. We could save most of that time by answering the phone ourselves. Some of us put a letter back into the envelope after we have read it—unproductive work.

We make reports or file papers which will never be referred to again. We read magazine articles which have no immediate value to us. We do all of these things, probably because we are not sufficiently jealous of our time.

After Mr. Burbank suggested to me that I might accomplish more by doing less, I made a list of things I did which were not necessary to accomplish the purpose I had in mind. I was astonished at its length. Each day I added one or two more. I still follow the practice of questioning the value of everything I do, with the result that I use less and less time for unnecessary work and accomplish more.

Often, a friend asks: "How in the world do you get time to write books, give lectures, write articles, and operate a farm in addition to your salaried job? I can't find time to do anything but the things I have to do." I usually suggest that my friend make a list of everything he does in addition to his salaried work, and then check the list to indicate those things which must be done to accomplish his purpose in life. I predict that he will end up with about 50% of the items unchecked. Those are the unproductive activities. Often, too, those activities actually consume twice as much time as the necessary items which he checked.

I seldom find any disagreement with the principle: "We must have the nerve to discard what is below standard or useless." However, most people don't believe they are doing any unnecessary work—not until they experiment with a check list.

The seven principles I have listed increase accomplishment—unfold a life of service. They can become a natural part of your daily living if you will review the list frequently and think of each item whenever you can use it in moving toward your goal—a life which contributes daily to the welfare of mankind. If you keep a record of the services you perform, you will learn that daily contributions are normal—not unusual.

ALGEBRA CAN CONTRIBUTE TO READING COMPREHENSION

A. C. Nelson
Manlius, New York

Have you ever been inconvenienced because you read something inaccurately? Learning to read carefully is not easily developed, but like most other worth-while habits it can be mastered.

Unless they are constantly reminded and supervised, most youngsters will read superficially. Now, in mathematics there is much that demands careful scrutinizing for successful comprehension. In this connection, algebra may be regarded as a means of promoting the habit of careful reading.

During the first half of the year of algebra, the emphasis is placed on acquaintance with the tools of this new science. But the "word problems" are the proving grounds for testing the students' ability to reason and to read carefully.

If one reads superficially, he is seldom able to solve problems correctly. The "word problem" then demands very careful reading as well as reasoning and, unless the student has learned to read carefully, this part of mathematics contains additional difficulties and remedial reading should be introduced to supplement the mathematics work.

On the other hand, if a student can work "word problems," it goes without saying that he has read correctly, reasoned accurately, and, in addition, used the mechanical tools of algebra successfully.

There are not many instances where one is able to check positively that his interpretation of the printed word is correct. But, here in the "word problems" in mathematics he can irrefutably demonstrate that he has read correctly. This habit can be transferred to reading of the newspaper, to following directions given anywhere—and this should be a desired end no matter what line of work a person enters.

MOTION PICTURES FOR ELEMENTARY SCIENCE*

George Greisen Mallinson
Western Michigan College of Education, Kalamazoo, Michigan

In an earlier issue of School Science and Mathematics[1] there appeared a list of films which were judged to be of value for use in courses in high-school science. This study is one of many devoted to use of such aids at this level. However, a recent report prepared by the Committee of Publishers[2] indicates that the need for further study in the field of visual aids is much greater at the elementary-school level than it is at the secondary. Therefore, the purpose of this study is to suggest, for use by elementary-school teachers, those films which may have value for courses in elementary science.

It was decided arbitrarily to select for each of the categories of topics for general science identified by Curtis[3] those films which in the opinion of the reviewers were best suited for contributing to the major objectives of science teaching at the elementary-school level as stated in the Thirty-First[4] and Forty-Sixth[5] Yearbooks of the National Society for the Study of Education.

From the various science films listed in *Educational Film Guide*[6] were selected those whose content might be of value for the purposes just mentioned. These films were then obtained from various film libraries, chiefly those of the University of Michigan and the University of Iowa. All of the films were then reviewed by the author, and by a specialist in the field of elementary education, and in some cases by an additional person who was either a specialist in science education or in elementary education. After having viewed the films the reviewers filled out the Rating Sheet for Films for Elementary Science (See Appendix). Those films which were judged as "Excel-

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* Acknowledgment is due Mr. Waldemar Gjerde of Iowa State Teachers College, Harold E. Sturm, Principal of Waterville High School, Waterville, Iowa, and Mrs. Charlotte Bishop of Western Michigan College of Education for assistance in evaluating the films. Special credit is due Mr. Erwin Schumacher, Instructor in Science, Burlington, Iowa for developing the form used for evaluating the films and for his assistance in evaluation.

[1] Mallinson, George G., and Gjerde, Waldemar C., "Motion Pictures for High School Science," School Science and Mathematics, XLVIII (October, 1948), 525–534.

[2] Committee of Publishers (Philip A. Knowlton, comp.), *A Report to Educators on Teaching Films Survey.* New York: Harper and Brothers, 1948. Pp. vii+117.

[3] Curtis, Francis D., *A Synthesis and Evaluation of Subject-Matter Topics In General Science.* Boston: Ginn and Co., 1929. Pp. 83.

[4] "A Program for Teaching Science," *Thirty-First Yearbook of the National Society for the Study of Education, Part I.* Chicago: Distributed by the University of Chicago Press, 1932. xii+369 pp.

[5] "Science Education in American Schools," *Forty-Sixth Yearbook of the National Society for the Study of Education, Part I.* Chicago: Distributed by the University of Chicago Press, 1947. xii+306 pp.

[6] Cook, Dorothy E., and Borden, Barbara (comp.), *Educational Film Guide, Annual Edition,* September, 1947. New York: H. W. Wilson Co., 548 pp.

lent" or "Acceptable" for use in Elementary Science by all the reviewers were included in the list which follows.

The following list includes the categories of science topics for which the films were recommended, the title of the film, whether best suited for primary (P) and/or intermediate (I) levels of the elementary school, whether a sound (Sd) or silent (Si) film, the number of minutes required for presentation, a series of code letters designating the film publisher (ex., COR), and a brief statement of the content of the film. If the film is colored the letters (cld) follow the type of film. Appended to the study are the addresses of the various publishers together with their designated code letters.

AIR

**Air in Action* I Sd (cld) 10 COR

Demonstrates the science of aerodynamics by explaning simple parlor tricks in terms of scientific principles. Animated drawings are used to explain the principles and applications of air in action.

*The description of the film is read thus: The film, *Air in Action*, was judged to be of value for developing the topic, "Air." The film has a sound track, is colored, has a running time of 10 minutes, and is published by Coronet Instructional Films (COR). It was judged to be of value for the intermediate level (I).

ASTRONOMY

The Earth and Its Seasons I Sd 10 KB

Explains the changes of seasons and the equinoxes and solstices. The angles at which the sun's rays strike the hemispheres in the different seasons are used to explain the differences in amount of light and heat.

What Makes Day and Night I Sd 8 YA

Shows how day and night are caused by the rotation of the earth, and how the side of the earth toward the sun is experiencing day, and the side away from the sun is experiencing night. Uses a globe to illustrate this movement, as well as the direction of it.

BUILDING MATERIALS

Shelter I Sd 10 EBF

Depicts the effects of climate and materials on types of shelters man uses, and man uses the raw materials available to suit his needs, i.e., adobe houses, use of brick, cement and steel in modern structures.

Trees and Homes I Sd (cld) 18 W

Shows the history of the tree from standing timber to the completed home. Show how trees are grown, harvested and how various sizes and types of lumber are manufactured from the tree. Depicts the use of waste products and scrap for manufacturing construction materials.

CLOTHING

Clothing I Sd 10 EBF

Shows the development of manufacturing processes for textiles from the early hand methods to modern mass production. Stresses the influence of climates on types of clothing worn.

Clothing for Children I Sd (cld) 11 COR

Presents the styles and types of clothing for young children. Emphasizes the types for various ages with respect to health value and practicality.

Making of Shoes I Sd 11 EBF

Shows how shoes are manufactured in modern American factories from the leather to the finished product.

CRUST OF THE EARTH

The Earth's Rocky Crust I Sd 11 EBF

Shows the formation of sedimentary, igneous and metamorphic rock using animated diagrams. Shows how soil is formed by the weathering of rock.

The Work of Running Water I Sd 10 EBF

Describes the effects of running water on the surface of the earth. Shows how dikes, alluvial fans, meanders and waterfalls are formed.

Wearing Away of the Land I Sd 10 EBF

Relates how land is affected by chemical action, glacial movements, and wind and wave action. The formation of caves, icebergs and glaciers is shown.

What is Soil? P, I Sd 11 FI

By using simple experiments shows the nature of soil. Describes how soil is formed and how man depends upon soil for his life.

ELECTRICITY AND MAGNETISM

Magnets I Sd 13 YA

Demonstrates a few of the basic facts about temporary and permanent bar magnets and their behavior. By means of experimentation two young children learn how magnets repel and attract one another and how the lines of force pass through materials such as glass and paper.

The Flow of Electricity I Sd 10 YA

Describes the flow of electricity by means of a simple demonstration in a home situation. Explains the phenomenon of electricity as the flow of electrons through a closed circuit. Shows the use of insulation on wires.

ENVIRONMENT

Science and Superstition I Sd (cld) 10 COR

Teaches students how to differentiate between science and common superstitions by means of simple classroom projects. Emphasizes the need for developing the habit of thinking critically.

Spring on the Farm P, I Sd (cld) 10 EBF

Shows how plants and animals becoming adapted to changes in seasons will interest children. Shows appearance of animals, growth of plants. Covers the months of March, April and May.

Summer on the Farm P, I Sd (cld) 10 EBF

Illustrates the growth of plants and animals during the summer season. Shows the activities of such animals as fish, frogs and dragon flies. Shows crops growing in summer, cultivation of corn and growth of flowers. Covers the months of June, July and August.

What is Science I Sd (cld) 10 COR

Presents the application of the "scientific method" which begins with curiosity and proceeds through observation, setting up and testing of hypotheses and arrives at a conclusion.

Winter on the Farm P, I Sd (cld) 10 EBF

Depicts winter as the time when plant and animal activities slow down, when food is scarce, and when domestic animals need the maximum of care. Shows tracks of winter animals and activities of birds. Covers the months of December, January and February.

FIRE

Our Common Fuels I Sd (cld) 10 COR

Depicts how man takes basic fuels from nature and then makes other fuels from them. Compares the values of these fuels on the basis of heating value, cost, convenience and cleanliness.

FOOD

Bread P, I Sd 10 EBF

Tells the story of bread from the wheat harvest, through the flour mill, and finally to a modern bakery. Illustrates the importance of machinery and mass production in the food industry.

Eggs P, I Sd 10 EBF

Shows the production of eggs on a large commercial farm. Emphasizes the care and feeding of flocks, gathering and cooling of eggs, and finally candling, grading, cleaning and packing.

Fundamentals of Diet I Sd 10 EBF

Classifies food in terms of its function in nutrition. Shows how the young of both plants and animals are provided with these foods. Gives examples of many foods in each of the classifications and shows what happens when the diet is deficient in them.

Milk P, I Sd 10 EBF

Shows how milking is carried on by hand and machine at a dairy farm. Shows the need of immediate cooling, transporting to bottling works, pasteurizing and finally bottling.

HEALTH EDUCATION

About Faces I Sd (cld) 20 USPHS

Portrays the gradual appreciation of an American family for the necessity for preventive dentistry, early dental care, and proper mouth hygiene. Relates the dental experiences of a young man from pre-school age through adulthood.

Defense Against Invasion I Sd 12 COIA

By animation shows how antibodies are built up in the bloodstream to counteract diseases. Emphasizes the values of immunization.

Joan Avoids a Cold P, I Sd 10 COR

Shows how violation of rules of good health makes one susceptible to colds. Shows how a young child avoids a cold, and how parental cooperation is needed.

Your Ears I Sd 10 YA

Explains and illustrates the structure and function of the human ear. Animated diagrams are used to show how sound waves are received and are transmitted to the inner ear. The effect of colds upon the ear are stressed.

Your Eyes I Sd 10 YA

Uses animation, as well as action, to illustrate the structure and function of the human eye. Shows how eye is protected by eyebrows, eyelashes and eyelids. Shows causes of, and methods of correction for, nearsightedness and farsightedness.

Your Teeth I Sd 10 YA

Illustrates and explains the structure, growth and care of the teeth using live action and animation. Shows how baby teeth are replaced by permanent. Explains how and why teeth decay, and shows proper methods for brushing them.

HEAT

Distributing Heat Energy I Sd 11 EBF

Describes the various sources of heat such as coal, gas, electricity, oil and wood. Shows how heat is distributed by conduction, convection, and radiation. The use of insulating materials for houses and containers is explained.

LIGHT

None Judged As Suitable

LIVING THINGS

Baby Animals P, I Sd 10 YA

Introduces and explains such concepts as degree and type of parental care in different animals, and the relationships among the number of young, amount of parental care, and chances for survival.

Birds of Prey I Si 15 EBF

Shows the characteristics of various birds of prey such as hawks, owls, vultures and eagles. Shows the unusual structure of their eyes, beaks, feet and feathers.

Birds of the Dooryard P, I Sd (cld) 10 COR

Uses a telescopic-lens color camera to show the details of the living habits of common birds such as the sparrow, robin and wren. Shows the common nesting places of these birds.

Butterfly Botanists I Sd (cld) 10 COR

Dramatizes the life histories of some of the more common butterflies throughout the egg, larva, chrysalis and adult stages. Shows how these animals find the plants they need for food.

Cecropia Moth I Sd 15 EFS

A photographic reproduction of the life history of the Cecropia moth from the egg to the adult stage. Depicts the eating habits and the spinning and shedding of the cocoon.

How Animals Defend Themselves P, I Sd 10 YA

Deals with the way in which animals have become adapted for protection against other animals and nature. Protective adaptations such as speed, claws and beaks, camouflage and mimicry are shown.

How Animals Eat P, I Sd 10 YA

Deals with the concept of how animals have become adapted for food-getting in order to survive. The film deals with food-getting mechanisms such as webs, teeth, claws and poison mechanisms.

How Animals Move P, I Sd 10 YA

Shows how animals are adapted to move in order to get food and to survive. Emphasizes the various ways in which animals have become adapted such as the development of wings, fins and legs.

How Nature Protects Animals I Sd 10 EBF

Shows how animals survive by means of protective coloration and by other protective adaptations such as speed, mimicry, armor, odors and hidden homes.

Honey Bee I Sd 11 EBF

Depicts the life history and activities of the honey bee. Stresses the community life of the honey bee and its part in pollination of flowers.

Leaves I Sd 10 EBF

Shows how the leaves are related to the other parts of the plants. Using cross-sectional views of trunks and leaves of trees, describes the processes of photosynthesis. Animation, microphotography and time-lapse photography are used.

Life in a Drop of Water I Sd (cld) 10 COR

Uses microphotography to show the tiny organisms such as amoeba, spirogyra and paramecium living in a drop of water. Shows how the life processes of these plants and animals meet the same life problems as do the higher forms of plants and animals.

Our Animal Neighbors P, I Sd (cld) 10 COR

Acquaints children with the habits and appearances of the many small animals which make their homes near them. Shows animals such as rabbits, squirrels, chipmunks, mice, moles and bats. Encourages the child to look for these animals.

Pigs and Elephants P, I Sd (cld) 10 COR

Explains how the common pig is related to such animals as the wart-hog, the elephant and the hippopotamus. Their similarities, and the characteristics which distinguish them from each other are illustrated.

Plant Growth I Sd 10 EBF

Uses the pea plant to illustrate the life cycle of plants from the opening of the flower, through seed germination, growth of roots, stalk and tendrils. Cross-pollination and streaming of protoplasm in pollen tubes is shown by microphotography.

Poultry on the Farm P, I Sd 10 EBF

Pictures the appearances and habits of young and adult chickens, ducks, geese and turkeys. The natural sounds of these birds are reproduced on the sound track.

Robin Redbreast P, I Sd 10 EBF

Tells the story of a family of robins from the time of nest building until the fledgling robins are old enough to take care of themselves.

Snakes I Sd (cld) 10 COR

Emphasizes the fact that most snakes are harmless and describes the four poisonous snakes found in the United States. Shows the life habits and adaptations of the harmless varieties.

The Bear and Its Relatives P, I Sd 15 COR

Attempts to correct false beliefs concerning the racoon, panda, brown bear, polar bear and black bear. Depicts the living habits of these various animals which are related.

The Care of Pets P, I Sd 10 EBF

Dramatizes the proper care of household pets such as the dog, cat, canary and goldfish. Emphasizes the need of humane treatment of animals.

The Cow and Its Relatives P, I Sd 10 COR

Shows how the cow is related to such animals as the zebu, the yak, the kudu, and the giant eland. These animals are photographed in their native habitats.

The Deer and Its Relatives P, I Sd 10 COR

Describes the adaptations of members of the same family of animals to life in different parts of the world. The deer, camel, llama, and giraffe are used to show how related animals vary when living under different conditions of environment.

The Growth of Flowers P, I Sd (cld) 10 COR

Uses time-lapse photography to show flowers sprouting from the ground, blooming and finally dying. In ten minutes shows a process covering a period of about ten weeks.

The Horse and Its Relatives P, I Sd 10 COR

The characteristic habits of the members of the horse family are illustrated. The zebra, tapir, rhinoceros, burro, draft horse and saddle horse are described from the viewpoint of their social and economic significance.

The Robin P, I Sd (cld) 10 HNP

Relates the story of the robin from arrival in the North at spring, until return to the South in the fall. Shows life activities of gathering food, building nests and rearing a new brood. Shows the relationships among robins, thrushes and bluebirds.

MATTER AND ENERGY

Simple Machines I Sd 11 EBF

Shows the basic features of the simple machines—the lever, the inclined plane, the wedge, the pulley and the screw. Applications of these devices to modern complex machines are demonstrated. Animated drawings are used to clarify the mechanical principles.

STUDY OF INDUSTRY

Behind the Scenes at the Airport I Sd 10 TF

With a transport pilot as a guide the class is taken on a trip about the airport. Shows the overhauling and testing of engines and the activities necessary for operating and maintaining an airport.

New Automobiles I Sd 27 AM

Describes the many products needed for building automobiles and shows the activities taking place on the assembly line for constructing automobiles.

Paper I Sd 10 EBF

The story of modern paper making from the forest to the finished sheets. Shows how trees are cut, sawed, chipped, made into pulp and then into paper.

Trees to Tribune I Sd 30 CT

Traces the manufacture of paper from the forest tree to the final printed edition. Emphasizes the activities involved in publishing a modern daily.

SOUND

None Judged As Suitable

WATER

Clean Waters I Sd (cld) 20 GE

Portrays the importance of our natural waters. Tells the story concerning the annual loss in the United States due to water pollution. Emphasizes the danger of such pollution to fish, wild life, water systems, recreational facilities and public health.

Our Water Supply I Si (cld) 14 GR

Shows how the water supply originates from rainfall, how it is purified naturally, and how later it becomes contaminated. Depicts the various processes used in purifying the public supply.

WEATHER AND CLIMATE

What Makes Rain I Sd 10 YA

Explains the processes of evaporation, condensation, and precipitation as they apply to the water cycle. Shows how water evaporates from puddles, wet clothes and tea kettles, and how the water vapor condenses when it cools. These processes are used to explain the occurrence of rain and other forms of precipitation.

APPENDIX A

ADDRESSES OF FILM PUBLISHERS

(AM) Automobile Manufacturers Association, 320 New Center Building, Detroit 2, Michigan
(COIA) Coordinator of Inter-American Affairs, U. S. Office of Inter-American Affairs, Washington, D. C.
(COR) Coronet Instructional Films, 65 E. South Water Street, Chicago 1, Illinois
(EBF) Encyclopaedia Britannica Films, Inc., 20 N. Wacker Drive, Chicago 6, Illinois
(EFS) Educational Films Service, 180 N. Union, Battle Creek, Michigan
(FI) Films, Inc., 330 W. 42nd Street, New York, New York
(GE) General Electric Co., Visual Instructions Service, 1 River Road, Schenectady, New York
(GR) Greenwich High School Photoplay Club, Greenwich, Connecticut
(HNP) Heidenkamp Nature Pictures, 538 Glen Arden Drive, Pittsburgh 8, Pennsylvania
(KB) Knowledge Builders, 625 Madison Avenue, New York 22, New York
(TF) Teaching Films, Inc., 2 West 20th Street, New York, New York
(USPHS) United States Public Health Service, Washington, D. C.
(W) Weyerhaeuser Sales Co., First National Bank Building, St. Paul 1, Minnesota
(YA) Young America Films, Inc., 18 E. 41st Street, New York 17, New York

APPENDIX B

RATING SHEET FOR FILMS FOR ELEMENTARY SCIENCE

Title__________ Sd____ Si____ Time____ BW____ Color____

Publisher__________ Address__________

Is the aid accurate and authentic? ________

Is the photography good? ________

Is the sound good? ________

Is it up-to-date? ________

Are the titles or commentary adequate? ________

Use of film Introduction ________

Contributory ________

Summary ________

Grade level for which best suited Primary ________

Intermediate ________

Secondary ________

Subject area for which best suited (Check those suitable):

______ Air	______ Health Education
______ Astronomy	______ Heat
______ Clothing	______ Light
______ Crust of the earth	______ Living things
______ Electricity and magnetism	______ Matter and Energy
______ Environment	______ Study of Industry
______ Fire	______ Sound
______ Food	______ Water
	______ Weather and Climate

General Description:

Rating of film for use in Elementary Science

Excellent ______________

Acceptable ______________

Not Acceptable ______________

____

Name of Reviewer

ON WORK AND ENERGY

Quoted by JAMES B. DAVIS

Lower Merion Senior High School, Ardmore, Pa.

How Hard Does a Typist Work? When Susie, the stenographer, comes home in the evening from her daily grind at the office and declares that she feels as tired as a ditch-digger, don't laugh at her, you big husky he-members of the family, You'll only be showing your ignorance.

Inquisitive mechanical engineers, with dynamometers and sliderules, have been checking on Susie's work; and, boys their findings are positively startling! They say she does more work than a ditch-digger!

Here's the way it's figured. A pressure of twelve ounces is exerted with each stroke on a typewriter key. A speedy typist will hit these keys 30,000 to 40,000 times per hour, resulting in an expenditure of energy equivalent to that required to lift about fifteen tons of dirt. If she types steadily eight hours a day at that speed, she will use as much energy as would be required to shovel more than a hundred tons of dirt!

No wonder she's too tired to help with the supper dishes when she gets home. And on top of the exhaustion of physical energy, there's the mental fatigue incident, perhaps, to having a cantankerous cuss for a boss who talks from his stomach, with his tongue wrapped around a cigar, and starts dictating a stack of rush letters at 4 p.m.

All this physical and mental labor she performs, mind you in many cases, on an expenditure of only twenty cents for mid-day sustenances—fifteen cents for a milk shake and a nickel to call up "Joe."—(From *The Prism*)

THE FOLKLORE OF CHEMISTRY: A SEQUEL[1]

E. W. Blank
Woodwild Terrace, Metuchen, N. J.

It is a long jump from the mad hatter in "Alice in Wonderland" to chemistry and the relation is perhaps not apparent at first sight. As a matter of fact the term "mad as a hatter" arose from the circumstance that hat makers formerly were subject to mercury poisoning arising from the handling of mercury employed to increase the felting properties of commercial furs. This poisoning manifested itself by shake and mental disturbances (2) and led to the common use of the term "mad as a hatter." It is only recently that the very real dangers associated with the handling of mercury have been fully appreciated.

Quicklime does not destroy human corpses as many murderers have found to their chagrin. None the less detective story writers have promulgated this belief in numerous murder mysteries. A recent example, among many, is that of Stephen Keeler in his detective novel entitled "Man with the Crimson Box" (3).

Alleged cures for the hiccups are legion. Some are fanciful in the extreme but a few are based on scientific fact even though not guaranteed cures. One of them states that breathing into a paper bag will stop an attack of hiccups. The basis of this treatment consists of inhibiting the phrenic nerve by forcing the patient to breathe more deeply than normal. Inhalation of 5% carbon dioxide in air or oxygen will accomplish this result. Breathing into a paper bag is a ready method of obtaining the desired increase of carbon dioxide in air.

In the writer's former paper allusion was made to the fact that salt brine that would float a potato the size of an egg was sufficiently concentrated to be employed in the curing of ham. Analogously we are informed that the proper concentration of lye for soap making can be judged by floating an egg or potato in it. If a section of the surface as big as a ninepence shows above the surface the lye is sufficiently concentrated.

Contrary to popular belief thunderstorms do not sour cream. The sultry weather generally preceeding a storm brings about the souring.

The Chinese have an adage: "Drop a feather down the well, if the feather falls in circles the air is impure; if it falls straight down the air is pure" (4). This may be explained by assuming that a turbulency of the atmosphere in a well may be due to currents of carbon dioxide or methane seeping into the well. On the same page the adage that a fire may be kept alive by placing a walnut in the coals is more difficult to explain.

Turning now to painting we must first explain a peculiarity possessed by some types of gels. It has been found that certain colloidal suspensions have the property of setting to a gel when left undisturbed and reverting to a fluid state when subjected to mechanical force. This sol-gel transformation is known under the term thixotropy (5). For this reason a paint should be well mixed by stirring before use even though the pigment appears to be already uniformly disturbed in the oil base. Consequently a painter is justified in slapping and working paint on the surface instead of merely "pasting" it on.

It has been claimed that one must have an eye for 4-leaf clovers in order to successfully find them. Four leaf clovers have a slightly different color from regular clover and this facilitates their discovery by

TABLE I. MISCELLANEOUS ITEMS OF CHEMICAL FOLKLORE

Empirical Operation, Phenomenon or Adage	Modern Scientific Explanation
[1] "German Silver" contains silver.	"German Silver" is an alloy of copper (56–60%), zinc (20–25%) and nickel (20–25%).
[2] Counterfeiters employ amalgam in their nefarious art.	Amalgam is far too soft and too expensive to be employed (10).
[3] Cane sugar is sweeter than beet sugar.	Sugar from beets and from sugar cane is identical chemically. Both are equally sweet.
[4] Snow is the poor man's fertilizer (i.e. enriches the soil).	Rain and snow both wash nitrogen and sulfur compounds out of the atmosphere (7).
[5] Stones grow.	Not true. In many cases stones in a field appear to become more numerous due to erosion of the soil.
[6] Flatirons age and will no longer hold the heat.	True. A tarnished iron (old) will lose heat more rapidly than a brightly polished (new) one.
[7] Crab meat is difficult to digest.	Crab is one of the most acid foods (8).
[8] Spider webs staunch the flow of blood when laid on a wound.	True. A coagulating agent is present. However a serious risk of infection exists.
[9] The staling of bread is due to loss of moisture.	There is no appreciable reduction of moisture in stale bread. The change is due to an alteration in the state of starch called retrogradation (9).

a person with an eye trained for color (hue) differentiation.

In the former paper allusion was made to the circumstance that in many cases the superstitions of native tribes have a basis in fact. It is interesting to note in this connection that the eating habits of various peoples are related to the deficiencies of diet arising from their environment. Thus for the Mexican peon the lime employed in the treatment of corn during the preparation of tortillas supplies a deficiency in calcium that would otherwise be serious. In an analogous manner hot chili helps provide the Mexican with vitamin A (6).

Photographers frequently lament that their cameras are "slowing up," by which they imply that longer exposures are necessary to photograph a particular subject than were formerly required. This is particularly true of old lenses and is due to a gradual yellowing of the glass over a period of years. The cause of this yellowing is conjectural but it is probably the result of a fungus growth. In extreme cases it will be found that with such a lens a cloud filter is no longer required.

Additional items of chemical folklore are given in Table I.

In conclusion the writer repeats an adage peculiar to Pennsylvania; "Never run over a snake with an auto as the snake fangs may lodge in the tires and poison one later." At the risk of horrifying my naturalist friends it suffices to say that a snake fang is essentially a hollow tooth, harmless enough by itself, and it cannot poison one unless it is connected to a posion sac and the poison forcibly injected into the body.

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Much of the significance of accumulated knowledge lies in an understanding of the process by which it was accumulated.

—JAMES B. CONANT

ANSWERING CHILDREN'S QUESTIONS THROUGH SCIENCE EXPERIENCES*

ANTHONY CORDELL
Grayling School, Detroit, Michigan

Man is on the road of progress. Behind him are superstitions and beliefs that things cannot be different. Ahead is progress and a better life for us all. All we need to go ahead is the scientific method and a scientific attitude that will enable us to understand and control our environment for a better life. It is our task to help this generation understand the place of man in his world. It is up to us to train our children in the use of the scientific method of working and thinking and develop in them a scientific attitude that will give them a happier life.

All this must be done through education. A scientific attitude must be developed early in the child's life before society surrounds him with needless fears and misconceptions. One of the places to do this is the science room where we can give children experiences that will motivate their thinking to a sound scientific attitude. There we can show them the folly of superstition and magic, and replace these with cause and effect relationships.

THE SCIENCE ROOM

Children like the science room. Even the kindergarten children look forward to a visit to the science room. What is there about that particular room that appeals to them? It doesn't seem to make much difference whether the science is taught in a home room or a science room. They like it whether it has tables and chairs or fixed seats. They like it because of what they do and the experiences they get there. Children like to come to the science room to work out everyday problems. They like to come and observe interesting things that challenge their curiosity. They like to come because there they can handle and manipulate things and experiment. There they can bring their dead bird or mouse, the butterfly they caught, their pretty rocks, a frog or toad, or their sick goldfish. There they can bring their questions and learn how to find the answers. It is up to us to provide them with a variety of experiences that will help them to find the answers to their questions through the scientific method of observation and experimentation.

Many of the experiences the children get are quite incidental, and

* Read at the Elementary Science Section of the Central Association of Science and Mathematics Teachers at Indianapolis, November 26, 1948.

are initiated by the children themselves. They often bring in interesting things they find after school or on trips. The children themselves present these things to the class. We make observations and discuss them. Many of these things are labeled and put on the museum table for others to see. The plants and the live animals in the room contribute many pleasant experiences for the children. They learn a great deal by caring for the animals, handling them if advisable, and making observations.

Animals Prepare for Winter

As fall advances children see many common animals disappear. They wonder what becomes of them. There are many experiences that we can give the children to help them see how some animals get ready for winter. If possible, take frequent walks in the fall to see squirrels burying acorns. Call their attention to the fact that the squirrels are storing food for winter. Encourage children to bring in grasshoppers and crickets. Make a screen cage for them and let the children care for them. In this way they will see them lay eggs and then die. Wooly bear caterpillars can also be kept in a screen cage. As fall advances the children will see that the caterpillars are spinning cocoons to get ready for winter. If possible, make a home for a pet toad. Let the children feed and care for it. Some day when they go to feed the toad, they will discover that he has buried himself in the dirt at the bottom of his home. Explain to them that the toad wants to hibernate so he will be ready for winter.

These simple experiences are important in the lower grades where we are teaching children science appreciation. They do much to correct false ideas about harmless animals. Through such experiences the children are stimulated to go on to wider interests in their leisure time; to make a home for a pet of their own, or make a museum at home.

Spring Activities

Other experiences the children get in the science room are in the form of planned experiences. These experiences are planned by the teacher and pupils together. All the children in the room have a part in the planned experience. These planned activities often grow out of incidental experiences. A child brings in some frog eggs some day in spring. We look at the eggs and discuss what will happen to them. Some child asks, "How can we keep these eggs so we can watch them change into tadpoles?" So a home is planned and made for these eggs. Other planned experiences are making cuttings, planting bulbs for the room, planting seeds for our garden, making leaf prints, etc. Some planned experiences like keeping a weather calendar may extend over

a long period of time, but they give the child more contact with science materials, and stimulate him to better use of leisure time.

Air Requires Space and Exerts Pressure

Many of the science experiences in the lower grades are directed toward helping children understand their everyday environment. Experiences are planned that give children contact with the elements of their environment in such a way that they establish concepts which lead to understanding, and dispel fears and misconceptions. Children have many pleasant experiences in playing with air toys. They bring these experiences to the science room, and want to know, "What is air?" To help them see that air takes up space all around us float a cork sailboat on some water in a battery jar. Ask the children to push this sailboat to the bottom without touching it, and without getting the sail wet. After some discussion and experimenting they say it cannot be done. Now invert a glass tumbler over the sailboat and push it to the bottom of the water. The boat goes down to the bottom without touching the glass. Let the children repeat this experience for themselves. Let them feel the boat and the inside of the tumbler to see that it is dry. Now the children want to know, "What pushed the boat down without letting water get in?" Repeat this experiment, but this time tip the glass slightly under water. They will see bubbles of air come out of the glass, and the boat rise in the glass as water comes in to take the place of the air that went out. Repeat the experiment with "empty" jars or a milk bottle. The children will see that things which seem empty are really filled with air.

Children also have many experiences with wind toys. They ask, "What is wind?" To help them see that wind is air in motion, ask the children to move their hand quickly back and forth in front of their face. They can feel the air move. Then give them some pieces of card board. Let them put some milkweed seeds in the air and move them about with the wind they can make using the pieces of cardboard. Next, let them blow the seeds in the air. Call their attention to the fact that each time they blow they have to take in a new breath of air. Ask the children to bring in air and wind toys and demonstrate to the class how they work.

Sometimes children bring up the question, "What would happen if jars and things were really empty?" The varnish can experiment will demonstrate that air exerts great pressure because of gravity. Put about a half inch of water in a clean varnish can that can be sealed tightly. Put the can on an electric hot plate until steam comes out for a few minutes. Explain to the children that the steam takes the place of the air in the can. Now remove the can from the hot plate and put

the cap or cork on it securely. As the steam inside the can condenses, the can will buckle and flatten in from all sides. Explain to the children that the air outside the can is pressing on it trying to take the place of the air that went out.

An even simpler experiment that the children can do to show air pressure is putting an egg into a milk bottle. Remove the shell carefully from a hard-boiled egg. Now ask the children to push the egg into a milk bottle without breaking the egg. After a few try it, they will discover that you cannot push the egg in with air in the bottle. Now wet the egg with water. Fold a paper drinking straw twice, light the two ends together, and drop it into the milk bottle. While the straw is burning well, place the egg, small end down, over the mouth of the bottle. As soon as the flame goes out the egg will be forced into the bottle by the air outside the bottle. To get the egg out first wash out the bottle with clean water. Then hold the bottle upside down against your face with the egg fitting tightly in the neck of the bottle. Force air into the bottle by blowing hard past the egg. Quickly remove the bottle from your face and the egg will pop out. Be ready to catch the egg.

What Makes a Plant Grow?

During the year occasions arise where we may want new plants to decorate the room, to plant in our garden, or to take home as a gift for mother. The question comes up, "How can we get new plants?" We discuss how plants can be grown from seeds. Children want to know, "What is a seed?" "What makes it grow?" To solve these questions soak some lima beans in water for a day. Let the children take these seeds apart to see the stored food and the baby plant inside. Other seeds can be planted in different soils and cared for to see which ones grow best. Some radish seeds can be placed between two sheets of wet blotting paper so we can see the roots and leaves grow out of the seeds. In this way children will see that seeds need certain care to grow.

If plants are wanted sooner than can be grown from seeds, make cuttings from coleus or geranium plants. Plant these in wet sand and later transplant them into pots of soil. Narcissus flowers can also be easily grown from the bulbs planted in bowls of pebbles and water. To help the children see what a bulb is let them take an onion bulb apart. Explain to them that an onion is a bulb just like our flower bulb. Have them plant some onions and compare their growth with our flower bulbs.

Fall Activities

In the fall when the leaves of trees are beautifully colored the children like to bring in these pretty leaves. They ask, "What can we do

with our leaves?" First grade children can make pictures of the leaves by placing a piece of paper over their leaves and rubbing a crayon over the paper. A picture of the leaf will form on the paper. These leaves can be cut out and pasted on a paper tree to make a fall tree for the room. The papers can also be put together to make a leaf book with all the leaves labeled.

Older children can make spatter prints of their leaves. All children get a big thrill out of making spatter prints. The technique is very simple and the result is a beautiful print of their leaf that can be used to make a leaf book, or be hung on the walls of the room. The only materials needed are a piece of white or colored drawing paper, a piece of screen, some water paint, and a small stiff brush like a toothbrush. A flat leaf is placed on the paper. Then the brush is dipped in the paint and rubbed back and forth on the screen held a little above the leaf. The bristles of the brush spatter tiny droplets of paint on the leaf and paper. When the leaf is removed, a print of the leaf is left on the paper. When using colored paper chose a contrasting colored paint.

An even simpler technique is to make chalk prints of the leaves. First wet the paper to be used. Place the leaf on the wet paper. Rub a piece of colored chalk gently on the screen held above the leaf. The chalk particles fall through the screen and stick to the wet paper. Be sure to use colored paper if you are using white chalk.

Children will want to label their pictures with the names of the leaves. They can copy the names from a leaf dictionary board in the room. This dictionary is made by putting up large labeled prints of the leaves on display. When the children want to find the name of their leaf, they compare their leaf with the ones on display and find the name.

Through these experiences children observe that different kinds of leaves have different shapes. They learn to know the names of the leaves by talking about them, and using the names. They also learn to work together. These activities can easily be repeated at home and lead to better use of leisure time. This same type of experiences can be repeated to help children learn the names of evergreen trees at Christmas time. Evergreen spatter prints can be made for Christmas cards, calendars, and place markers.

Winter Science

Some cold day in winter the children come to school talking about how cold it is outside. Perhaps they heard the weather report on the radio. They want to know, "How does the weather man know how cold it is? What does 'degrees' mean?" They will be stimulated to find out how a thermometer works. Let the children take a ther-

mometer outside and see the liquid go down where it is cold, and then go up again when they get back in the warm room. Repeat this experience in the room with a glass of cold water and a glass of warm water. They will see that heat makes the liquid rise in the tube. They will wonder why the liquid goes up where it is warm. To explain this fill a thin walled flask with some water colored red. Now fit the flask with a small glass tube in a one hole rubber stopper. Now place the flask on a hot plate or in some hot water. The liquid will rise in the tube. When the flask is cooled the liquid goes down the tube. Repeat this experiment letting the children put their warm hands around the flask. Explain that the liquid needs more room when it is warm so it goes up the tube.

After learning the meaning of the numbers on the thermometer the children can make a model thermometer to take home. The only materials needed are cardboard or stiff paper for the board and colored string for the liquid. Let the children copy the thermometer scale on the cardboard and draw two straight lines for the tube. Then punch a hole at the top and bottom of the tube they draw. Next take a piece of white string and red string a little longer than the cardboard. Tie one end of the strings together. Next pass the end of one string through the top hole. Pass the end of the other string through the bottom hole. Tie the two ends together on the back of the cardboard thermometer. Now they can make the red string, representing the liquid, go up or down by manipulating the string from the back. They get a lot of fun out of playing with their thermometer, and learn to read a real thermometer at the same time.

Magnetism for Children

Many children have experiences with magnets at an early age. Many have a toy magnet, a pair of magnetic dogs, or an electric magnet on their erector sets. They bring their magnet to school and want to know, "Why won't my magnet pick up everything?" To help them see that magnets only attract iron and steel give them an assortment of odds and ends of materials on which they can try a magnet. They will discover that only iron and steel things are attracted to the magnet.

The magnetic fish pond is an exciting experience that children like. Get some small celluloid or plastic fish. Cement a piece of small nail on the mouth of some of the fish. China cement can be used for this. Place the fish in a glass aquarium or in an aluminum pan filled with water. Let the children fish using a small magnet on a string for the hook. Soon they will discover that some of the fish cannot be caught. When they examine the fish they will see that only those with the piece of nail will be caught.

Children bring their magnetic dogs to school and want to know how they work. This can easily be shown by letting the children examine a bar magnet. Explain to them that there are two kinds of magnetism called north and south; that one end of the magnet has north magnetism, and one end has south magnetism. Then suspend a bar magnet horizontally with a piece of string. Let the children bring another bar magnet near this one, pointing a north pole toward it, then a south pole. After repeating this a few times they will discover that two like poles repel, and unlike poles attract. Explain to them that their little dogs are mounted on bar magnets.

Children often ask, "How does a compass work?" This can easily be shown by letting the children magnetize a large sewing needle by rubbing it on a magnet. When this needle is suspended horizontally by a piece of thread it always points north and south. The needle can also be floated in a glass bowl by pushing it through a piece of cork. Now if the children make a compass chart to go under the bowl, they have a compass. Compare the compass they made with a pocket compass to see if they act the same. Now ask the children to hold a bar magnet under the table beneath their floating needle. Call their attention to the fact that when you move the magnet under the table the needle moves with it. Explain to them that the earth is like a magnet with a north and south magnetic pole.

What Response Should We Expect?

In all our science lessons we must keep in mind that children's interests consist of activity rather than intellectual interests. Their interests are mainly on things they can do and things they can see. Children like to take things apart to see how they work. What boy has not wanted to take a clock apart? Children like to grow things themselves that they can pick, to keep a pet that they can feed, or make a rock collection that they can show to somebody else. It is part of our work to keep alive and stimulate this interest in how and why things work, and develop a scientific attitude of thinking. Children do generalize in terms of their experiences. We must stimulate them with a wide variety of experiences, then guide them to draw correct conclusions that help them understand the hows and whys of their everyday living.

Sometimes we feel disappointed when we do not get the response we want from a lesson. But, attitudes are developed slowly. They come through repeated experiences. Let us not forget that what a child experiences today he may remember for a lifetime. The impressions we make on his mind today may be there throughout his entire life.

ELEPHANTS OF YESTERYEARS

JAMES B. COPE
Earlham College, Richmond, Indiana

The elephant more than any other living animal appeals forcibly to the imagination not only on account of its great sagacity, but also because it is such an obvious link between the world of today and that of the distant past—the Pleiocene and Miocene times of 30–40,000 years ago. Kipling has helped the child to bridge this gap with his interesting and thrilling story of "How the Elephant got its trunk." Thanks to the many circuses and zoos throughout the country any school child can draw a reasonable likeness of this animal. We see, then, that the elephant plays a role in our society. It is not difficult for us to look back 30–40,000 years ago and visualize a similar beast existing at that time.

The tendency for us to think of animals of the past as so much larger than our present day species is a common mistake. A few million years ago when the Rocky Mountains were not yet born and the arid western plains were a land of lakes, rivers, and luxuriant vegetation, this region was inhabited by a strange race of mighty reptiles on which science has bestowed the name of Dinosaurs or Terrible Lizards. It was during this period that there were animals twice the size of our elephants called Brontosaurs or Thunder Lizards, whose thigh bones were six feet long and whose single vertebra $4\frac{1}{2}$ feet long. A Brontosaur weighed approximately four times as much as an elephant, i.e. five tons, which according to our standards is very heavy.

Another fact which has caused us to become confused regarding the size of prehistoric animals is the use of the scientific name of Mammut which was accepted as the genus of the early elephants. Mammut by easy transition led to Mammoth which word we are accustomed to use in describing anything remarkably large. It is easy to believe, therefore, that the name Mammoth was given to the now extinct elephant for its extraordinary bulk. This, however, is not true, although the original possessor of the name was a huge animal. The Siberian peasants called the creature Mamantic (changed later to Mammut) or ground-dweller, because they thought it was a large mole. The logic was simple and reasonable. No one had ever seen a live Mamantic, but there were lots of bones in and on the ground, and if nobody had seen it then, of course, it lived underground. For all practical purposes, although there were larger animals, the elephants of the past were about the same size as the elephants of today.

The Mastodon and Mammoth are the ancient elephants. The Asiatic elephant is a first cousin if not a great grandson to the Mam-

moth, while the Mastodon is a third or fourth cousin. One of the most striking differences between the two is the pattern of the teeth. The Mastodon has rooted teeth showing similarity to our teeth in having from 2–3 long pronglike projections extending down into the gums. The Mammoth, on the other hand, has continuous teeth, i.e. without distinct prongs, but an extension of the crown into the gums for anchorage.

For knowledge of the Mammoth's external appearance we are indebted to individuals found imbedded in the ice. We have all heard the stories of how as the creature gradually thawed the peasants grabbed the tusks and sold them for ivory; the dogs fed upon the thawing flesh in the day time and the beasts of the wild at night. Other frozen specimens, however, were found and enough evidence has been accumulated so that we know the Mammoth had a long and shaggy coat of hair which was adapted for living in the cold climate of the north. The birthplace of this animal is not certain, but the earliest known resting place is in the famous Cromer Forest Beds of England. From Europe he apparently went eastward into Asia and taking advantage of the land connection between Asia and North America travelled east as far as the Atlantic coast about the latitude of southern New York. Over all of this region greater or lesser abundance of bones and teeth have been found. It must be remembered here that the above description includes both ***Elephas primigenius***, the northern species, and ***Elephas Columbi***, the southern one. It is fairly certain that man and the Mammoth were contemporaries, at least in southern Europe. Not only have man's weapons been found with Mammoth bones, but crude sketches of the animal by primitive man have been found carved on slate or ivory. No evidence has been accumulated to show that man and Mammoth lived in North America at the same time.

The American Mastodon was about the same size as the Mammoth and probably the most widely scattered of all American vertebrate fossils. Its remains have been found at numerous localities from Alaska to Mexico. There were many species of Mastodons, but ***Mastodon Americanus*** was the most common and the one which is referred to in this paper. There has been no satisfactory evidence that the Mastodon and man were contemporaneous. The recentness of its extinction is indicated by bones discovered buried in swamps and retaining much of the animal matter. So recent, comparatively speaking, has been the disappearance of the Mastodon that it has been said that Thomas Jefferson thought it might be found in the northwest which during his lifetime was unexplored.

What caused the extinction of the Mastodon still remains a mystery. To say that it was exterminated by man is ridiculous. Neither can it

be said it was killed by unfavorable weather conditions, for they, by the evidence of the scattering of bones, were fairly adaptable to great climatic changes. They were as comfortable in the cool swamps of Michigan and New York as they were in the warm savannas of Florida and Mississippi. It is easy to blame the glacial epoch as being responsible for the extinction of animals. But this cannot be held accountable for the extinction of this animal because *Mastodon Americanus* came into New York after the recession of the great ice sheet and tarried so late that Collett states " . . . When the large bones were split open the marrow still preserved was utilized by the bog cutters to 'grease' their boots and that chunks of sperm-like substance $2\frac{1}{2}$ to 3 inches in diameter occupied the place of the kidney fat of the monster."

Why do animals become extinct? It is a human characteristic of educated men to wish to know the whys and wherefores of everything. It is a period of mental unhappiness for him until he can link the visible facts with some kind of theory. This age old question of the "whys" of extinction has yet to be answered. Is it evolution, over adaptation, scarcity of food, scarcity of shelter, survival of the fittest, disease, or what? There are examples of all of these and yet any one alone probably isn't the sole cause. Science will continue to grope for the answer, but life's stream will flow on, dropping one species on the one hand and picking up or producing another on the other hand. Man with all of his intellect will continually be humbled by the immensity of the problem which life itself presents both present and past.

ELECTRICAL FARM LIVING

A new 47-page booklet, "Electrical Ideas for Better Farming," containing information for putting electricity to work on the farm has been prepared by the School Service Department, Westinghouse Electric Corporation.

The booklet offers specific suggestions as to how electricity can be applied to dairy farming; to the raising of sheep, beef cattle, poultry, and hogs; and to the handling and care of crops, so that faster and more economical methods of farming can be worked out. The booklet gives detailed instructions for the construction of the electric time savers and aids discussed previously, and several charts are included which give the correct horsepower motor to use for each specific job. There are also hints on the repair and maintenance of electrical apparatus and household appliances. Better lighting methods are covered, and a brief discussion on wiring materials and methods is included.

The final section of the booklet is devoted to an explanation of the Better Methods Electric Contest sponsored annually by the 4-H Club Association.

Copies of the booklet for classroom distribution can be obtained, free of charge, from the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30, Pa.

A PRACTICAL PHILOSOPHY CONCERNING MATHEMATICS

JOSEPH J. URBANCEK
Chicago Teachers College, Chicago 21, Illinois

INTRODUCTION

It has facetiously been said that college is a place where people with lots of crust spend lots of dough to have one long loaf. Whatever may be the implied philosophy behind such remarks, it must in all seriousness be said that there are some people who feel the same way about our public schools. It becomes increasingly more important, therefore, that those charged with the administration and leadership of our schools know where they are going. Much discussion and activity has always been engaged in by the leaders and thinkers in any field who are not satisfied with the status quo and are sure they have the right answer. In the development of our theme two broad problems present themselves.

Someone figured that it would take 99 years for a student to take all the courses offered at the University of Wisconsin, as listed in one of their catalogues during recent years. The number of years that it would take to complete all the high school courses offered would not take nearly that long; but what is most important for the high school curriculum is what to put into it so that the diversified needs of our growing young may be met most adequately. That is one of the broad problems to which I referred, and the other, which is somewhat related, can best be introduced by the following fictitious incident.

A group of insurance executives were giving a banquet in honor of their star salesman, and at the appropriate time the honored one was called upon to explain the methods he used in achieving his successes. His description was brief and pointed. He said,

"I go out into the country in my car. I see boy in field. I say 'Come here.' He comes. I say 'You carry life insurance policy?' He say, 'No.' I say, 'You damfool sign here.' Then I go to next one."

That story has an implied philosophy which should deeply concern those of us in the schools. It has a vital bearing upon our attitude towards our curriculum. What we keep in it is of paramount importance. Our people, for their own protection, need facts, *and above all need to weigh them most carefully through reflection and analysis.*

A great number of men who have attained eminent goals of leadership and administration in various fields of official activity have, at one time or another, been teachers of mathematics, or highly proficient in the subject, or its related fields. Cases are on record where tottering commercial structures have been stabilized due to the fertile

brain of the one man who was able to *apply* the knowledge that he had. It has been true in all fields of endeavor that the stronger man has succeeded largely through his power of analysis where the weaker one has failed, mainly for lack of it.

Not so long ago, at an educational club bearing the name of a widely known educator, I heard statements that surprised and shocked me. I could hardly believe one man's statement in particular, when he said, "Why teach that dumb stuff, Algebra, anyhow?" He must have had the old algebras of abstract exercises in mind and not the up-to-date modern mathematics books. I inquired later of others who knew him, if the man were serious or if he were merely "baiting" the mathematics men who were there. I was informed that he was serious. No one questions the man's sincerity. However, nothing was proposed in place of the algebra. I was at a loss to know if the man, as well as others who believe as he expressed himself, *meant that no quantitative data involving functional relationships* was to be given in our schools. Factual information regurgitated without analysis, application, and reflection is ineffectual.

Social Efficiency

It is a pitiable thing to have individuals pass through our schools and grow to maturity and new responsibilities without a clearly conceived idea of the manifold problems related to such economically vital things as time payments, borrowing money, paying taxes, and the philosophy of frugality within limits of reason. Sociologists state that one of the two greatest factors that lie at the root of divorce is the economic factor, which undoubtedly carries serious implications concerning the structure of our future society. A better understanding of family finances doubtless implies a need for more practical mathematics.

Where can one more adequately study the problems chosen from the fields of science, art, home, community, trade, and business, than in the mathematics class? A cross section of the nature of these problems as found in the modern mathematics textbooks involves taxes, mortgages, interest, insurance, bills, installment buying, rent, investments, partnerships, business, commodities, and the many phases of the fields of science. The foregoing types of problems provide ample opportunity for social mathematics, science, spatial relations, symbolic thinking, and functional relations. A student in dealing with them gains facility in number sense and common sense, decimals and common fractions, signed numbers, graphs, simple statistics, formulas, simple equations, ratio, proportion, and symmetry. These are all essentials of the present and future citizens' equipment.

That there is a dearth of such knowledge of the essentials of mathe-

matics may be evidenced by the fact that at the University of Chicago, a test was given to the freshmen in simple fractions with startling results. As you well know those freshmen are definitely above the average, and although in college their mean score on the test was 65 per cent. What do you suppose would be the mean score of the majority of high school graduates? It is this high school group that is not likely to get further training in the essentials; whereas, most college students *are*, even *though* indirectly.

To more thoroughly understand the whole problem of the field of mathematics and its importance to society requires an understanding of society itself and much that has transpired during the past 50 years. Previous to the past five decades, few curriculum problems arose because the function of most secondary schools was to meet college entrance requirements. It is vital to the discussion that the picture of what has happened since be presented.

Social and Mathematical Changes

Two generations ago few people had occasion to come into contact with Tree Surgeons—few people had need for them. When a job arose whereby such professional services were needed most any local man was called who hacked away at the limbs or the tree, resulting frequently in irreparable damage to unusual and expensive trees. In course of time due to the increased complexities of living there arose a demand for trained men who could skillfully prune a tree without hacking it. The net result was an improvement in the quality of work brought about by specialization and the development of such a dignified title as Tree Surgeon. Men trained for the work actually make sick trees well and perform numerous duties that bring symmetry, beauty, and grace to one's home and community.

Mathematics—the Tree of Knowledge

The roots, trunk, heart, and limbs of all scientific progress have too often been hacked instead of pruned to bring about its best development. Frequently there were those who felt (judging from their writings) that the tree would bear more fruit, or give more shade, if chopped out entirely. There were others who believed that the hacking and pruning should be so severe that only the roots should remain; thus posterity would be denied the value and beauty of the foliage. In fact one may pursue the literature and find varying degrees of pruning designed to improve the subject based upon the philosophical objectives of the various writers. The range varies from extremely radical to extremely conservative. Sane pruning does not necessarily mean the eliminating of branches of the tree as a whole, for while a particularly small limb may be eliminated another, or two

or three others, may grow in such a fashion as to more thoroughly develop the tree. When pruning is thoroughly understood it is found that the same principles do not hold for all trees; that allowance must be made for the age of the tree as well as the type of tree, its degree of health, locality, and other considerations.

Two generations ago the manner of cultivating our tree, the Mathematical Tree of Knowledge, was quite different. Only a small percentage of grade school students went to high school. By means of natural selection, it has been argued in many theses, these students constituted mostly those with the higher intelligence quotients and those above the lower economic brackets. By the very nature of the historical development of the high school they were preparing for a goal beyond that in which they found themselves. They were preparing for college. Educators, through their various meetings, associations, lectures, writings, and publications perfected such devices, plans, programs, and paraphernalia as fitted the needs, educational theories and philosophies of the time. Thus developed compartmental mathematics in the high schools as the most effective device of accomplishing the goals set before the teachers. The goals mainly meant the meeting of requirements set down by the College Entrance Examination Board, the New York Regents, and other agencies that developed from time to time for the purpose of finding answers to their common problems. While these school problems were many and varied and involved all school subjects, those who dealt with mathematics pushed compartmentalism to the point that textbooks became mere drill books—i.e. catalogues of exercises of varying degree of design and difficulty. That is, perhaps, too harsh a criticism but it does describe a phase. *While this was going on in the schools the world was changing industrially, economically, and socially.*

Malthus, in his law of population, stated that population tends to outrun the food supply unless certain positive and preventive checks such as war, famine, disease, and celibacy operate to retard the growth. He did not, of course, foresee the power of human genius to discover and invent means of supporting an increasing population. Human beings tend not only to enhance their numbers, but also to develop an increasing quantity and variety of wants. Invention and discovery make possible satisfaction of these increasing desires. Human genius has had such a forceful effect upon our mode of living that no longer is the 84-hour work week necessary. As evidence of the change we need only be reminded that labor unions are no longer considered outlaw organizations, and the Federal Government, due to the great need, has supported a working week of less than half the number of hours that were considered essential and vital in the past.

Since the beginning of the century we have benefited from an ex-

ceedingly large number of inventions, improvements, and discoveries, in practically every phase of human endeavor. Mention of but a few should lead anyone to think of many others. The perfection and development of electricity alone has led to thousands of devices for human comfort and aid ranging through all phases of social living. Wireless telegraphy, and then radio and video has brought comfort and pleasure to untold millions. News events that are reported an hour after happening are sometimes stale and, in terms of a few generations ago, are considered as last year's news. Automobiles and other self propelled vehicles have revolutionized social living to such a degree as to be immeasurable—mathematically we may assume it to be incommensurate in social change and well being. The movie "stills" and finally the movie "talkies" have had their part in supplying "Extra-curricular" education. As a result of the numerous changes that were taking place so rapidly methods of manufacture were forced to keep pace.

One need not argue that the most elementary needs of human beings are food, clothing and shelter. Until these are satisfied no higher needs can develop. As men and women become more intelligent and more refined, they grow discontented with primitive types of food, shelter, and methods. Step by step as the human race has advanced in civilization its needs have become more numerous and varied. Purely material requirements being satisfied, other and higher demands arise. This becomes especially true with increased leisure time. The spiritual and social aspirations make their appearance. As mankind passes each stage in civilization it finds, through the growing control over nature, that purely material wants can be satisfied with less and less exertion. Men gain their daily bread today with infinitely less effort than in primitive times. The chief reason is that they have learned to act collectively in mastering the forces of nature; in other words they have achieved a high degree of economic organization; still the problem of a more equitable economic distribution is as perplexing as ever and requires the combined efforts of our greatest intellectual forces for solution.

The natural resources of the American continent were as great three hundred years ago as they are today; yet they were practically useless in satisfying human wants because the red man would not and could not bestow his labor upon them. It remained for the white man to transform natural resources into economic goods. This he has done not only by the use of muscular exertion but also by the application of intelligence. In applying their labor to natural resources men soon found that the best results could be obtained by apportioning different tasks to different workers. The making of cloth is no longer a trade but embodies a series of trades—that of the wool-carder, the

spinner, the weaver, the fuller, the dyer, and the finisher. In a modern shoe factory there are many more than twenty distinct operations in the making of a factory shoe, each requiring special skill on the part of the worker. In the whole of the Roman Empire it is said that only thirty-seven different trades and professions were in existence at that time. Today the number runs into the thousands; some having many hundred branches and divisions. It would be practically impossible to make a list of them all, although the Federal Government has a bulletin that lists most of them in classified form. A single rubber plant in the United States makes more than thirty thousand different kinds of rubber products, through its many specialized departments. This is the age of specialists. Men no longer call themselves shoemakers but cutters, lasters, welters, sole-makers. Even in the engineering professions, considering only the major divisions, we have electrical engineers, civil engineers, mechanical engineers, locomotive engineers, stationary engineers, mining engineers, marine engineers, chemical engineers, and engineer-custodians.

Division of labor has brought many economic advantages. It enables the worker, by constant practice at a single operation, to acquire skill and dexterity. It enables almost every worker to find some task that he is able to do and for which he has a special liking and skill. But the elaborate division of labor which marks modern industry with its high degree of efficiency and cheaper consumers goods also has its defects. It increases the monotony and irksomeness of labor. It does not develop the mind. It prevents the development of all-round craftsmen, men who can turn their hands to a variety of things. Hence when a worker in a modern industry loses his regular employment it is difficult for him to change to anything else. Confining one to the same, simple, monotonous, task daily is not conducive to an extension of intelligence; nor does great inspiration come for a man doing daily the twenty-first operation of a routine process. Division of labor has come to stay, however, and in spite of all the disadvantages the world is, on the whole, far better off for its coming. It has made the production of goods so much easier; so much cheaper to purchase.

Mathematical Adjustments

It becomes our duty, then, to take society where we find it and see what has been done, is being done, or should be done to meet the situation. More people have more time than ever before for leisure regardless of their occupation; only isolated instances are an exception. A working life is scarcely half as long as it was in 1900, due to shorter work days, weeks, and years. Hence efficiency in education becomes increasingly more important, since fewer employees are needed

to produce the nation's goods and food supply, and migration is constantly on the increase. The raising of the compulsory school age increased many fold the attendance in our high schools and brought with it a vast variety of abilities, a high percentage of which could not carry successfully the traditional mathematics. With the wider expansion of our social and economic structures schools felt the burden by being called upon to include in their curricula a larger and larger number of subjects, both of an academic and vocational nature. The load in turn fell upon the individual students. It was found that they were being overburdened with too many things in their school lives and so a process of pruning began in many subjects, slowly at first.

World changes in mathematics have occurred since 1910 but the discussions and some early efforts began before that. Referring to one phase, the simplification of algebra, the pruning to which I referred earlier, involved the elimination of the following topics from the elementary course; the highest common factor by division, cube root by use of the formula, the general theory of the quadratic, complicated brackets, complex fractions of a difficult type, simultaneous equations in more than three unknowns, the binomial theorem, and complicated radicals. Further—the old ideas that "we must scientifically define all terms before they can safely be used" and "we must develop the subject logically" were replaced by a psychological development. In place of the dreaded topics new materials were added in somewhat the same manner as the growing tree would grow new and better shoots when properly cultivated. Work in informal geometry, meaningful formulas, graphs, numerical trigonometry in the ninth grade, and other similar and related materials have crept into the course in keeping with the needs of our modern complex society. The early introduction of coordinate geometry has made possible the teaching of calculus in some high schools and the functional relationship between variables is being emphasized in many texts and in mathematical writings as a necessary unifying element in keeping with a wider and more understandable knowledge of the problems of present day society.

Mathematical Reflections

Since the objectives of the teaching of mathematics have been shown in the body of this paper let us turn now to a few selections from some of the masters.

David Eugene Smith[1] states, that we study mathematics because it

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[1] Smith, David Eugene. "Mathematics in the Training for Citizenship." Third Yearbook. National Council of Teachers of Mathematics, Pp. 11–23.

is linked up with a large number of branches of human knowledge; that it has a high degree of mental discipline; that it can be the poetry of the soul and has its poetic side as well as its practical; that it can rouse the soul to a contemplation of truths that endure; that it can make man conscious, as is possible in no other way, of his position in the universe about him; that it gives humanity a religious sense that can not be fully developed without it; and finally, the history of mathematics is the history of the race.

From W. S. Schlauch[2] we note that mathematics contributes to direct self-preservation, indirect self-preservation or the earning of a living, social efficiency and citizenship, and the pleasure of the individual, and a generous understanding of, and an insight into, economic, social and cosmic forces, and problems whose mastery is necessary for the continuing of human progress.

Conclusions

In attempting to meet such objectives as have been embodied in this paper it is recommended that all mathematics be offered as will meet a legitimate demand. It is fully recognized that the needs and capabilities of individuals vary to both extremes but there is sufficient mathematics to accommodate all types and it should be offered in a manner most fitting to the types involved and in keeping with the most efficient way of administering it in any system of schools. It would appear that about the most efficient way that this can be done would be to offer courses involving the principles that were enumerated earlier, namely: problems that provide ample opportunity for social mathematics, for science and its applications, for spatial relations, for symbolic thinking, and for functional relations. A student in dealing with such mathematics should gain facility in number sense and common sense, decimals and common fractions, signed numbers, graphs, simple statistics, formulas, simple equations, ratios, proportion, and symmetry. These are essentials of the present and future citizens' equipment.

Such courses should be required of everybody who goes to high school, but the program should not end there, for to end it there, would be arresting the development of those who are ready and want to go to other courses in mathematics. Although the courses would be required they could be circumvented by those who could pass proficiency examinations. The proficiency examinations could be taken upon their entrance into high school or preferably near the end of their eighth grade career. The scheduling of the freshmen classes could go on with as little interruption as in the past and those quali-

[2] Schlauch, W. S., "Mathematics as an Interpreter of Life," *Ibid.*, pp. 24–34.

fied could take such subjects as were offered them upon entrance, including, of course, such mathematics for which there is a legitimate demand—which means 2, 3, or 4 years, for those students who elect and who qualify. That is the humane thing to do in the light of democratic and forward looking principles.

Under a capable personnel system all students should have the advantages of all school subjects explained to them. Mathematics properly presented will not suffer in the competition and has much to offer the students of our high schools who, in course of time, will be shaping policies that may affect even you and me.

CORONET RELEASES NEW FILMS

THE CELL—STRUCTIONAL UNIT OF LIFE (One reel, sound, color or black-and-white; Collaborators: Walter A. Thurber, Ph.D., Professor of Science, and William B. Clemens, Assistant Professor of Science, State Teachers College, Cortland, New York). Here, through Coronet's amazing micro-photography, the living, simple cell is authentically presented. Students actually see the moving, living protoplasm in a leaf cell . . . see amoeba taking food, growing, dividing . . . become familiar with differences in the structure of the cell according to its function within the entire organism. This vivid film unforgettably teaches the basic relationship of our own living bodies to other living organisms. (Intermediate, Junior High, Senior High)

CLEANLINESS AND HEALTH (One reel, sound, color or black-and-white; Collaborator: N. E. Bingham, Ph.D., Professor, School of Education, Northwestern University). Students will never again believe that old saying, "A little dirt won't hurt you!" after seeing this important Coronet film. This is the story of David . . . his visit to a doctor . . . of the lessons in cleanliness which the doctor impresses upon him. Through Coronet's amazing micro-photography, the existence of dangerous tiny organisms all around us is unforgettably demonstrated, and the importance of cleanliness to good health is soundly established. (Primary, Intermediate)

MEASUREMENT OF ELECTRICITY (One reel, sound, color or black-and-white; Collaborator: Ira C. Cavis, Professor in the Teaching of Science, University of Wisconsin). David, concerned about overloading a household circuit, falls asleep while studying a book on electricity. In his dream, which follows, the four scientists, whose names have been adopted as the four basic units of electrical measure, speak to him from the book. In an unusual and forcefully effective treatment, this film teaches the fundamental definitions and the physical concepts involved in . . . the Volt, Ampere, Ohm, and Watt. It is an excellent teaching aid either alone or with Coronet's *Introduction to Electricity*. (Junior High)

PRINCIPLES OF SCALE DRAWING (One reel, sound, color or black-and-white; Collaborator: Harold P. Fawcett, Ph.D., Professor of Education, The Ohio State University). Wherever things are built, scale drawings are the language of construction . . . a vital means of communication. Jack, Gill, and Helen are building a booth for the Charity Fair. In solving their basic problems they instruct us in the skills and interpretation of scale drawing. Determining scale, using measuring and scaling tools, understanding terms, and the vital importance of scale drawing in modern industry are concepts and techniques applied in this excellent introductory film. (Junior High, Senior High)

THE LABORATORY AQUARIUM

D. B. Blauvelt and B. H. Carleton
Zoology Department, University of Portland, Portland, Oregon

A rectangular tank, approximately $8\frac{1}{2}''$ by $16''$, and $10''$ deep, filled with pond water, a few locally collected water plants and various snails, insect eggs and larvae, perhaps a few amphibian eggs, will establish a project of value in biology classes at all levels, including those from the primary grades through graduate research.

The water plants are oxygenators and also serve for instruction in photosynthesis, streaming of protoplasm observable in the various species of Nitella and Anacharis, root structure in Vallisneria, and reproduction and life cycles in the algae. Other possibilities will occur to the biology teacher.

Common, locally collected snails lay small egg masses easily removed to smaller containers for study from day to day. A small amount of calcium carbonate is used in tanks containing snails as a source of shell constituents.

The abundant tiny egg masses left by various insects on pond plants and leaves develop rapidly in the aquarium without special care. These may also be removed to smaller vessels for convenience.

Amphibian eggs are used sparingly, the jelly mass is removed as soon as the tadpoles have emerged. An oversupply will quickly ruin the balance in small aquaria, but a few tadpoles kept in the aquarium prevent a surface scum that forms when plants alone are used. Study of the amphibian eggs depends on the training of the class. Very young students will observe the macroscopic changes intelligently while older students may wish to do experimental work. The simple type of aquarium described below is selected because of its simplicity and economy. An aquarium can be considered as a cross section of a nearby pond, or a natural pond can be thought of as a natural aquarium. The simple, easily balanced small aquarium supplied only with locally collected materials constantly reflects the various life cycles occurring at the same time in nearby ponds.

Specific directions for the maintenance of aquaria have filled many volumes of the literature. Certain fundamentals of biology can be used to eliminate most of the pieces of equipment often recommended. Natural ponds are not equipped with aerators, heaters, thermostats, and the like.

I. The Tank

Four and five gallon rectangular type tanks are portable and most easily balanced. The tank is cleaned with dilute permanganate solution, rinsed thoroughly, and provided with a glass cover. Washed

sand or fine gravel is placed to a depth of two to three inches. The tank is placed near a window but not in direct sunlight for more than an hour or two a day because the sun will quickly heat a small tank.

II. The Water

Pond water is collected from large open ponds because it is not only free from chlorine but also supplies the microscopic plant and animal life of the pond. Large glass demijohns are very convenient for the collection trip. Some of the pond water is retained oustide the aquarium for use in smaller containers to study eggs and larvae.

"Conditioned" tap water is often used. This is ordinary tap water allowed to stand in the tank for two or three weeks. Water is poured into the tank on a piece of cardboard to avoid disturbing the sand.

III. Plants

Plants suitable for aquaria may be collected locally. They are washed in dilute permanganate, rinsed, and planted if non-floating. Any of the weaker disinfectants may be used in place of permanganate if the strength is kept at a minimum.

The various species of Nitella, Sagittaria, Vallisneria, Anacharis, and Cabomba are commonly used. Cabomba is most commonly used but only because of its convenience. Most of the other plants are better oxygenators.

Professional and hobby aquarists shun locally collected plants preferring "aquarium grown" material. The teacher uses native plants as a means of teaching the pond life of the region and for emphasis on natural conditions. Many of the "pond weeds" grow well in small aquaria.

IV. Animals

A vast business has been built on imported tropical fish. Some of these have value in the laboratory, but a complete aquarium can be maintained without resorting to the pet stores and aquarists' establishments. If tropical fish are selected, heaters, thermostats, and sometimes aerators must be purchased.

Beautiful aquaria are maintained from the commonest types of pond snails, insect eggs and larvae, a few amphibian eggs and tadpoles, or such other aquatic forms as are brought in from time to time by students. The greatest danger is that of overloading the aquarium with animal life. Conservation can be taught by insisting that nothing is brought in from collecting trips that is not required for some definite purpose. Anything that is not definitely needed should be left in the pond.

Careful examination of the aquarium will usually disclose a con-

siderable supply of protozoan life. Small crustacea can be introduced, but their voracious habits suggest care if other organisms are maintained with them.

V. The Use of Fish Eggs

Fish eggs that are nearly transparent have a place in most laboratories. The eggs can be used to demonstrate all the important stages of early vertebrate embryology and are easily studied in the living state without injury to the eggs.

Of the many aquarium fish producing eggs the so-called Japanese Medako (*Oryzias Iatipes*) has been most convenient. Schools of 20 to 30 fish are maintained in eight and ten gallon aquaria without special heating. They produce adhesive eggs almost daily at dawn, the eggs being deposited on plants in the aquarium. If desired, groups of two males and a single female can be bred in small one gallon fishbowls kept at about 80°F. Eggs develop in ordinary finger bowls which may be kept in the warmed aquaria on a small shelf.

Live food is desirable for Medako. Adult fishes may be fed "white worms"—the Enchytrae, or dried fish foods are obtainable from aquarists.

VI. Food

For snails, calcium carbonate is supplied either directly or in the form of marble chips left in the aquarium. Snails also consume finely powdered cereals, such as millrun, finely divided fish powders, or compounds of one part dried raw lean meats to three parts of a powdered cereal. Snails cannot develop normally in the presence of fish often given to nipping exposed snail parts.

Cultures of protozoa are maintained as sources of food, especially for smaller animals and baby fish. Water weeds are kept in ordinary glass jars until decay of the weeds is noticed, and Infusoria and Rotifera develop. They are then "transferred" by placing a few drops of the surface scum in a pint jar prepared with an ordinary hay infusion. This is made by adding two or three dozen short lengths (about one inch) of the stalks of alfalfa or timothy hay and about a dozen grains of whole wheat or polished rice to a pint of water. This is boiled for ten minutes, then allowed to stand for a day.

For mass cultures equal quantities of the culture containing the protozoa and the hay infusion are mixed. This is then placed near a window and allowed to stand for a week or two.

Euglena require a culture made from split peas or polished rice. About two or three dozen grains of polished rice or split peas are boiled for 30 minutes in a pint of water. This is allowed to stand for 24 hours in a clean glass jar. At the end of twenty-four hours mix

equal parts of the culture containing Euglena and the fresh pea or rice infusion. Place this culture near the light and allow to stand for several days. Stir any scum that collects to avoid oxygen lack.

Daphnia magna are collected from ponds with ordinary nets. They are easily maintained in the small one-gallon fishbowls if a small amount of dried fertilizer, such as horse, cow, or sheep manure is added. They are used as live food for fish.

Enchytrae (white worms) are obtainable from most aquarists. A wooden box is filled with soil to a depth of three or four inches. The soil is carefully selected for freedom from debris, moistened slightly with water and some milk. The worms are placed on the soil, covered with pieces of bread moistened with milk. Ordinary mashed potatoes may be substituted for the bread. The covering is renewed once a week. The box is kept in a shady place with an average temperature of about 60°F. About two weeks will be required to produce a culture ready for use. The soil is kept in a finely divided condition and if found sour is placed in sunlight for a few hours until the surface has dried. A very few worms are fed daily. Overfeeding quickly destroys the balance in aquaria.

VII. References

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(3) *The Aquarium*, a periodical published by the Innes Publishing Co.

(4) Rugh, Roberts, *Experimental Embryology*, Burgess Publishing Co., 1948. This book includes an authoritative section on the practical aspects of aquarium fish culture with emphasis on types suitable for laboratory purposes.

(5) U. S. Bureau of Fisheries, *Notes on Aquarium Snails*, Washington, D. C.

(6) *Aquarium News*, a periodical published by the Rochester Aquarium Society, 100 South Ave., Rochester, N. Y.
See especially in this periodical the following two articles: Halsey, H. Randolph. Lecturer in Zoology, College of Pharmacy, New York City, "Live Food for Baby Tropicals," IV: 24 (1934).
Marcus, Henry C., U. S. Bureau of Fisheries, "Propagation of Water Fleas (Daphnia magna)," IV: 2 (1934).

LILIENTHAL URGES SPEED-UP IN ATOMIC ENERGY EDUCATION

Education of American youth about the facts and meanings of atomic energy is urgently needed, says David Lilienthal, Chairman, U. S. Atomic Energy Commission. In *Atomic Energy: Here to Stay*, Mr. Lilienthal calls on the whole teaching profession to meet "a desperate need for the raw materials of atomic energy education." *Atomic Energy: Here to Stay* has been published by the Federal Security Agency, Office of Education, in cooperation with the U. S. Atomic Energy Commission as a supplement to the March issue of *School Life*, the official monthly journal of the Office of Education.

PLANT MORPHOLOGY AS A LIVING SUBJECT

Dorothy V. Phipps
Chicago Teachers College, Chicago, Ill.

A course in beginning college morphology may be made a very live, interesting study. It may also become routine in technique and so unrelated to life situations that students often lose interest in it except as it gives credit or fulfills sequence requirements.

That students might gain interest by coming to see that the structures they were studying had a vital relationship to the function and habitat of the plants studied and to the use to which they were put by man, techniques given below were introduced into a three-semester hour course meeting five times a week. One lecture-discussion period was supplemented by four single hour laboratory periods. In this limited time, a careful selection of forms from the lowest to the highest plants had to be made. The method of presentation and techniques used also had to be carefully considered with the time element in mind. While many instructors in the field of morphology probably are using the following techniques these notes were written with the hope that some of the suggestions might be of value to those instructors not already employing them.

The general outline of study followed much the ordinary pattern of a morphology course with the study of macroscopic and microscopic structures, as well as life cycles, of plants important in the evolutionary sequence. However, fresh material was used as much as possible throughout the course for the macroscopic study and also for that microscopic study which required only simple staining devices. Preliminary observations were supplemented with commercially prepared slides, as our students had had no previous experience with and no time to learn the complex staining processes required for finer details. Dried and preserved material supplemented living material. Charts, lantern slides, moving pictures, models and the seoscope were also used. A few of the special devices follow.

Thallophyta. During the study of the green algae, the algae in the laboratory aquaria were examined. Students were encouraged to bring in fresh water algae and begin aquaria on their own time. Some of these forms were studied under the microscope. Structures were related to the life habits as found by observation from the aquaria and ponds and streams from which the plants had come. Land forms, such as pleurococcus, were obtained from tree bark, old flower pots and boards in the green house.

The study of the red and brown algae led to the ordering of living specimens from a laboratory supply company. These were kept in sea water in a wooden tub in the laboratory. Here students were able to

see how the air bladders of fucus supported the plants, to find the receptacles with the openings of the conceptacles, and to look for the sperms released from them. A silent film *Life Cycle of Rockweed* showing algae of the sea was used. This gave students who had never seen the sea a picture of the natural habitat of these plants and helped to clarify certain points, such as the fertilization of the egg and other features of the life cycle. The students were greatly interested in locating, identifying and drawing the various types of algae from the salt water collection. *Algae, The Grass of Many Waters** was read and reported upon.

When the fungi were briefly studied, students brought in a large amount of material. Mushroom spawn was kept in terraria and its development observed; spores were seen to be liberated in clouds from the puff-balls; bracket fungi and lichens found in their natural habitats were studied. Not all students participated in bringing in material although many did. Those who could not, were anxious to examine the materials brought by others and helped in caring for them. Corn smut, lilac mildew and several other disease-producing fungi were gathered and studied, simple microscopic slides being made. Commercially prepared slides, preserved material and Riker mounts supplemented the material for life cycles which the students could not obtain by themselves. Economic importance as well as adaptations of the structures was emphasized.

Bryophyta and Pteridophyta. Students brought in a few liverworts, Sphagnum and true mosses as well as ferns obtained during field trips in a course in taxonomy. It was easier for students who had gathered these plants to understand many of the structural relationships of the plants to their habitat as they had seen these first hand. Some living forms were ordered from a biological supply house. The students were divided into groups, each group being given a glass bowl, jar or aquarium in which to set up a terrarium with the materials obtained. The plants in these were cared for by members of the groups after the class sessions. Many of the terraria were very lovely. A few students spent considerable thought in attempting to duplicate natural habitats. The reproductive structures of Marchantia, Anthoceros and some of the other liverworts were of great interest to the class. Some growth and development took place in most of the terraria. Some of the capsules of mosses formed, dried, opened, releasing their spores; fern fronds grew and unfurled exposing the sporangia. To study the great variety of sporophyll forms and distribution of sporangia among the ferns, the study of living forms was supplemented by herbarium specimens. Fern spores obtained from a supply house showed de-

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* *Algae, The Grass of Many Waters* by Lewis H. Tiffany. Charles C Thomas, Springfield, Ill. 1938.

velopment as did culture tube fern prothallia obtained from the same source. Alternation of generations was more clearly understood when the class could correlate their readings, preserved specimens, charts and microscope specimens with actual growing material.

A short trip to the railroad embankment at the edge of the campus was taken to observe Equisetum growing and to obtain some for laboratory study. Specimens of Lycopodium and Selaginella were obtained and grown. Fossils were used in discussions relating to evolutionary sequence.

Spermatophyta. Spermatophytes were considered in much the same way as previous groups. Wherever a structure had particular value to man, this was pointed out. A trip through the campus was taken to relate certain morphological structures studied with size, growth habits and success in ecological environments. As no gymnosperms were growing in the immediate neighborhood, preserved material and Riker mounts were studied as well as specimens of leaves, cones, twigs and cross sections of young conifer tree trunks brought from Michigan and Wisconsin by students who had summer homes there. Of course, a study of the standard prepared slides occupied most of the class time.

While the above treatment may appear to some instructors to approximate a course in general botany, this was far from the case. The majority of the class time was spent in a serious study of the morphology of plants. Standard basic drawings were made with resultant notebooks which, in the instructor's opinion, were comparable with those of a more formal morphology course.

Two outcomes seemed apparent as the result of this method of teaching. One, a greater interest on the part of the students than has been indicated by those who, within the writer's experience, have taken the course given the traditional way; and two, a better idea of the relationship of structure to function and function to life as related to that of the student.

NEW MOVIE ON MOTION STUDY AVAILABLE

"The Easier Way," a two reel 16 MM (twenty-one minute) sound motion picture has been produced for the General Motors Employee Relations Staff by The Jam Handy Organization, and is now available for showings to interested groups in industry without charge. The purpose of this film is to show that motion study of production operations usually makes the workman's job easier. It is a photoplay treatment picture in which a foreman and his wife dine with a motion study man. During the action a peg-board is introduced to demonstrate the fact that motion study in all departments of a business can improve the production rate as well as make the work easier. For details, write to James Craig, Film Section, Department of Public Relations, General Motors Corporation, 9-252 General Motors Building, Detroit 2, Michigan.

OPTICS NOTES

K. L. Yudowitch
The Florida State University, Tallahassee, Florida

Two concepts in geometric optics seem to be an inexhaustible source of confusion for students: virtual images and magnification. Both concepts can be clarified by a single expedient.

We are wont, many of us, to view our physical science as an absolute study of inanimate nature. But we know physics to be an empirical science. Whether it suits our pattern or not, the only means by which we directly perceive light is via two instruments which we carry about on our heads.

The simple true statement that all observed optical systems must finally form a real image on the retina of the eye rather startles the student who has only read his text. However, this statement is soon the source of clarification.

I. Virtual Images

A virtual image is described to the student as an apparent source of diverging rays, an image formed behind an opaque mirror, the little image that isn't there!

The fiction of a virtual image loses much of its mystery when the student realizes that he doesn't "see a virtual image." An enlightening construction shows the divergence by a lens or mirror of the rays from an object which are then converged by the eye-lens onto the retina. The virtual image, shorn of its mystery, remains an occasionally useful fiction.

II. Magnification

Magnification is often defined as the ratio of image to object size or the equivalent ratio of image to object distances from the lens or mirror. Then too we may define magnification as the ratio of the angles subtended by the image and by the object at the observer's eye. No wonder the student becomes confused!

The magnification of an instrument for direct visual observation may be defined as the size of the image formed on the retina with the instrument to the size of the image on the retina formed without the instrument. This leads immediately to the equivalent expression for magnification as the ratio of the angles subtended at the eye with and without the instrument. This definition will suffice for all experiments involving direct visual observation.

It is true, however, that for some work such as photographic projection one might desire to consider the real image-to-object size ratio. It would be convenient to denote the two concepts by different terms

such as "visual-magnification" and "real-magnification." However, as such terms are not commonly accepted, it is doubly important that we clearly distinguish between the two meanings of the ambiguous term "magnification."

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

2120, 2. *Ben B. Bowen, Chico, Calif.*

2120. *Orville F. Barcus, Philadelphia, Pa.*

2125. *Proposed by Felix John, Ammendale, Md.*

Through the excenters of triangle ABC lines are drawn parallel to the three sides, thus forming another triangle $A'B'C'$. Prove that the perimeter of triangle $A'B'C'$ is $4r \cot \frac{1}{2}A \cot \frac{1}{2}B \cot \frac{1}{2}C$, where r is the radius of the circumcircle of ABC.

Solution by C. W. Trigg, Los Angeles City College

Let the equicenters be I, I_a, I_b, I_c. Let the feet of the perpendiculars from I_b to AC be D, from I_c to AB be E and from A' to I_bI_c be F. We shall employ the relationships $a=2r \sin A=4r \sin \frac{1}{2}A \cos \frac{1}{2}A$, etc.; and $\cot \frac{1}{2}A+\cot \frac{1}{2}B+\cot \frac{1}{2}C=\cot \frac{1}{2}A \cot \frac{1}{2}B \cot \frac{1}{2}C$.

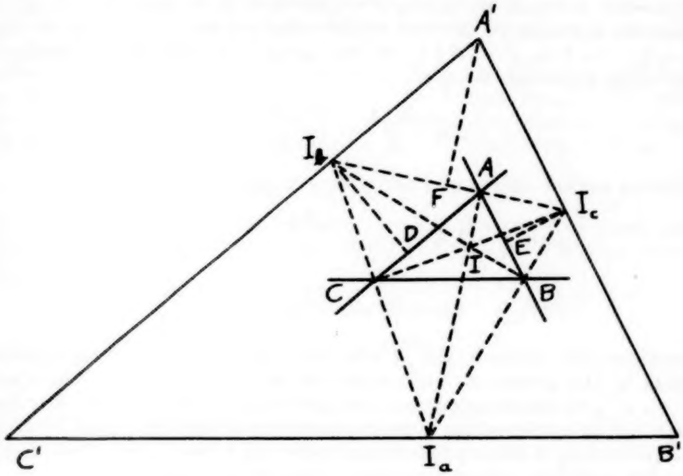
$I_bI_c \perp AI$, $I_cE \perp A'B'$, and $I_bD \perp A'C'$. It follows that $\angle DI_bA=\angle DAI=\frac{1}{2}A=\angle IAE=\angle AI_cE=\frac{1}{2}A'$. Also, $\angle A'I_bA=\angle I_bAD=\angle EAI_c=\angle AI_cA'$. So, triangle $I_bA'I_c$ is isosceles and $I_bF=FI_c$.

Now D and E are points of contacts of escribed circles, so $DA=s-c$ and $EA=s-b$. Then $I_bA=(s-c) \csc \frac{1}{2}A$, $AI_c=(s-b) \csc \frac{1}{2}A$, so $I_bI_c=a \csc \frac{1}{2}A$. Hence $I_bF=\frac{1}{2}I_bI_c=\frac{1}{2}a \csc \frac{1}{2}A$ and $I_cA'=I_bA'=\frac{1}{2}a \csc^2 \frac{1}{2}A$. In like manner, it may

be shown that $I_aB' = I_cB' = \frac{1}{2}b \csc^2 \frac{1}{2}B$ and $I_aC' = I_bC' = \frac{1}{2}c \csc^2 \frac{1}{2}C$.

Therefore, the perimeter of $A'B'C'$ is

$$\begin{aligned} p &= a \csc^2 \tfrac{1}{2}A + b \csc^2 \tfrac{1}{2}B + C \csc^2 \tfrac{1}{2}C \\ &= 4r(\sin \tfrac{1}{2}A \cos \tfrac{1}{2}A \csc^2 \tfrac{1}{2}A + \sin \tfrac{1}{2}B \cos \tfrac{1}{2}B \csc^2 \tfrac{1}{2}B + \sin \tfrac{1}{2}C \cos \tfrac{1}{2} \csc^2 C) \\ &= 4r(\cot \tfrac{1}{2}A + \cot \tfrac{1}{2}B + \cot \tfrac{1}{2}C) = 4r \cot \tfrac{1}{2}A \cot \tfrac{1}{2}B \cot \tfrac{1}{2}C. \end{aligned}$$



Solutions were also offered by W. J. Cherry, Berwyn, Ill.; and Hugo Brandt, University of Maryland.

2126. *Proposed by Hugo Brandt, College Park, Md.*

Prove the identity: $\sec x + \tan x = \cot(\pi/4 - x/2)$.

Solution by Cecil B. Read, University of Wichita

$$\begin{aligned} \sec x + \tan x &= \frac{1}{\cos x} + \frac{\sin x}{\cos x} = \frac{1+\sin x}{\cos x} \\ &= \frac{1+\cos(\pi/2 - x)}{\sin(\pi/2 - x)} \\ &= \frac{1}{\tan \frac{1}{2}(\pi/2 - x)} \\ &= \cot(\pi/4 - x/2), \end{aligned}$$

making use of the standard identity

$$\tan A/2 = \frac{\sin A}{1+\cos A}.$$

Note: This identity is needed in order to reconcile apparently contradictory formulas frequently found for $\int \sec x \, dx$.

Solutions also offered by: Margaret Joseph, Milwaukee, Wis.; M. Philbrick Bridgess, West Roxbury, Mass.; Norma Sleight, Winnetka, Ill.; C. W. Trigg, Los Angeles, California; William A. Richards, Riverside, Ill.; Max Beberman, Shanks Village, N. Y.; W. J. Cherry, Berwyn, Ill.; Linus Guggenberger, Collegeville, Minn.; C. N. Mills, I. S. N. U. Normal, Ill.; A. MacNeish, Chicago, Ill.; M. Zwicky, 917 Harvey Ave., Oak Park, Ill.

2127. ***Proposed by Norman Anning, University of Michigan***

Given the curves: $y=x^3-3x$ and $x=y^3-3y$. Show that the positions of all nine of their intersections are by straight edge and compasses constructible.

First Solution by W. J. Cherry, Berwyn, Ill.

Substitute $x^3=3x$ for y in the second equation. We get $x(x^8-9x^6+27x^4-30x^2+8)=0$. $x=0$ is one root. By letting $x^2=y$ we find other roots: 2, -2, $\sqrt{2}$, $-\sqrt{2}$. The depressed equation for $x^8-9x^6+27x^4-30x^2+8=0$ determined by the roots 2, -2, $\sqrt{2}$, $-\sqrt{2}$ is $x^4-3x^2+1=0$. By using the quadratic formula or the resolvent cubic equation, we get

$$x=\frac{\sqrt{5}\pm 1}{2},\quad \frac{-\sqrt{5}\pm 1}{2}.$$

The following are the values of x and y for the points of intersection:

$$x=0,\ 2,\ -2,\ \sqrt{2},\ -\sqrt{2},\ \frac{\sqrt{5}\pm 1}{2},\quad \frac{-\sqrt{5}\pm 1}{2}.$$

$$y=0,\ 2,\ -2,\ -\sqrt{2},\ \sqrt{2},\ \frac{-\sqrt{5}\pm 1}{2},\quad \frac{-\sqrt{5}\pm 1}{2}.$$

It is evident that, given a unit of measure, the line segments representing the coordinates of the points of intersection of the curves can, by the operations $+$, $-$, $\div$, $\sqrt{\ }$, be constructed with straight edge and compasses. For instance, we can get $\sqrt{5}$ by constructing a mean proportional between 1 and 5; we can get $\sqrt{2}$ by constructing a mean proportional between 1 and 2; and the other operations involve addition, subtraction and bisection of line segments.

Second Solution by Norman Anning, University of Michigan

If we put $x=2\cos A$, then $y=2\cos 3A$, and $x=2\cos 9A$. In order that $2\cos 9A$ shall be equal to $2\cos A$, we must have either $8A$ or $10A$ equal to an integral number of revolutions. It follows that x and y are "constructible" for each of the nine solutions because, as is well-known, the regular octagon and regular decagon are constructible.

The curves intersect in (x, y) where $x=2\cos A$, $y=2\cos 3A$, and $A=0°$, 36°, 45°, 72°, 90°, 108°, 135°, 144°, 180°.

Solutions also by: C. W. Trigg, Los Angeles City College; Wm. A. Richards, Riverside, Ill.; J. Slavin, Brooklyn, N. Y.; A. MacNeish, Chicago, Ill.

2128. ***Proposed by V. C. Bailey, Evansville, Ind.***

If the squares of the sides of a triangle are in A.P., show that the tangents of its angles are in H.P.

Solution by Aaron Buchman, Buffalo, N. Y.

If h_c is the altitude to side c of triangle ABC, then it is easily shown that

$$\cot A+\cot B=c/h_c. \qquad (1)$$

But, if K is the area of triangle ABC, then

$$h_c=2K/c. \qquad (2)$$

From (1) and (2), it at once follows that

$$\cot A+\cot B=c^2/2K. \qquad (3)$$

Similarly

$$\cot B+\cot C=a^2/2K \qquad (4)$$

$$\cot C+\cot A=b^2/2K. \qquad (5)$$

But the given condition is equivalent to the relation,

$$a^2+b^2=2c^2. \tag{6}$$

Replacing a^2, b^2, c^2 in (6) by means of (3), (4), (5), and simplifying, gives

$$2 \cot C=\cot A+\cot B. \tag{7}$$

From (7) the cotangents of the angles of triangle ABC are in arithmetic progression. Therefore, their reciprocals, the tangents of the angles of triangle ABC, are in harmonic progression.

Solutions also by: Adrian Struyk, Paterson, N. J.; Max Beberman, Shanks Village, N. Y.; C. N. Mills, I.S.N.U. Normal, Ill.; Norma Sleight, Winnetka, Ill.; V. C. Bailey, Evansville, Ind.; C. W. Trigg, Los Angeles; Norman Anning, Univ. of Michigan; Wm. A. Richards, Riverside, Ill.; A. MacNeish, Chicago.

2129. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Derive the relation which can be used to write the set of integers, such that the square of each of these integers is equal to the sum of the squares of two consecutive integers.

Solution by the proposer

It is required to solve, in integers, the equation,

$$y^2=x^2+(x+1)^2. \tag{1}$$

Let

$$=2y+2x+1 \tag{2}$$

and

$$q=y+2x+1. \tag{3}$$

From relations (2) and (3) it follows at once that

$$=p-q \tag{4}$$

and

$$x=\tfrac{1}{2}(2q-p-1). \tag{5}$$

Using relations (4) and (5) to replace x and y in relation (1), and simplifying, there results

$$p^2-2q^2=1. \tag{6}$$

But relation (6) is in the form of Pell's equation, $p^2-aq^2=1$, which is solved completely, in integers, by the relation, $p+q\sqrt{a}=(P+Q\sqrt{a})^k$, where k takes all integral values, and P, Q give the least positive solution.

Applying this formula to relation (6) there follows

$$p+\ \sqrt{2}=(3+2\sqrt{2})^k \qquad k=1, 2, 3, \cdots\ ]. \tag{7}$$

From relation (6), p must be an *odd* integer. Thus, from relation (5), x is always an integer. Therefore all integral solutions yielded by relation (7) will yield integral solutions of (1). Thus the required relation is given by the pair, (4) and (7)

A table showing the first seven values of x and y follows.

x	0	3	20	119	696	4059	23660	etc.
y	1	5	29	169	985	5741	33461	etc.

Solutions also by: C. W. Trigg, Los Angeles City College; Max Beberman, Shanks Village, N. Y.; Hugo Brandt, Univ. of Maryland.

2130. *Solution by C. W. Trigg, Los Angeles City College*

Inspection shows that if one side of the original triangle be taken as the base then the constituent triangles may be divided into two classes, one with third vertices above their bases and the other with third vertices below their bases. In each class the number of triangles containing 1, 4, 9, etc. elemental triangles each may be considered as the sum of an A.P. When the triangles with third vertices above their bases are enumerated, we have

$$S_1=[1+2+\cdots+n]+[1+2+\cdots+(n-1)]+\cdots+[1+2+\cdots+(n-\overline{n-1})]$$
$$=n(n+1)/2+(n-1)n/2+\cdots+1\cdot 2/2=\frac{1}{2}\sum_{n=1}^{n}(n+1n)$$
$$=n(n+1)(n+2)/6.$$

If $n=2K$, then the number of triangles with third vertices below their bases is

$$S_2=[1+2+\cdots+(2K-1)]+[1+2+\cdots+(2K-3)]+\cdots$$
$$+[1+2+\cdots+(2K-\overline{2K-1})]$$
$$=(2K-1)\cdot 2K/2+(2K-3)(2K-2)/2+\cdots+1\cdot 2/2=\sum_{K=1}^{K}K(2K-1)$$
$$=K(K+1)(4K-1)/6=n(n+2)(2n-1)/24.$$

Hence, for n even, the total number of triangles is

$$S_1+S_2=n(n+2)(2n+1)/8.$$

If $n=2K-1$, the number of triangles with third vertices below the base is

$$S_3=[1+2+\cdots+(2K-2)]+\ 1+2+\cdots+(2K-4)]+\cdots$$
$$+[1+2+\cdots+(2K-\overline{2K-2})]$$
$$=(2K-2)(2K-1)/2+(2K-4)(2K-3)/2+\cdots+2\cdot 3/2=\sum_{K=1}^{K}(K-1)(2K-1)$$
$$=K(K-1)(4K+1)/6=(n+1)(n-1)(2n+3)/24.$$

Hence for n odd, the total number of triangles is

$$S_1+S_3=(n+1)(2n^2+3n-1)/8=[n(n+2)(2n+1)-1]/8.$$

Therefore, the total number of triangles for any n is

$$S=\tfrac{1}{8}\{n(n+2)(2n+1)-\tfrac{1}{2}[1+(-1)^{n+1}]\}.$$

Solutions were offered by C. N. Mills, Normal, Ill.; Hugo Brandt, Univ. of Md.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2118. *David Freeman and Warwick Tompkins, Tamalpais H. S., Mill Valley, Calif.*

2116. *Daniel Weiser and Tommy Burton, Ball H. S., Galveston, Texas.*

2126. *Roger S. Harris, Waukesha, Wis.; John Parker, Albert Ottavania, George Bray, New Trier High School, Winnetka Ill.; Donald Hemmer and Donald Post, Butler, N. J.*

PROBLEMS FOR SOLUTION

2143. *Proposed by Norman Anning, University of Michigan*

Establish the identity:

$$\sin P \sin Q + \sin R \sin (P+Q+R) = \sin (P+R) \sin (Q+R).$$

2144. *Proposed by Felix John, Ammendale, Md.*

Show that $n^{13}-n$, for every n, has the factor 2730.

2145. *Proposed by Olive Ireland, St. Albans, Vt.*

In the "ambiguous" case of plane triangles, show that the circumcircles of the two triangles are equal.

2146. *Proposed by Clara Lance, Chevy Chase, Md.*

If the sides of a triangle ABC be in arithmetic progression, and if a is the shortest side prove

$$\cos A = \frac{4c-3b}{2c}.$$

2147. *Proposed by Lillian A. MacDonald, Newark, N. J.*

If D_p is the difference between the sum of the pth powers of the first n consecutive even numbers and the sum of the pth powers of the consecutive odd numbers up to n, show that $2D_8+12D_6+2D_4$ equals the fourth power of a whole number.

2148. *Proposed by Francis L. Miksa, Aurora, Ill.*

Find the smallest set of three Pythagorean triangles whose perimeters are equal.

NATIONAL TRAINING LABORATORY IN GROUP DEVELOPMENT

The National Training Laboratory in Group Development will hold its third summer session again at Gould Academy, Bethel, Maine. The Laboratory will open June 19 and continue through July 8.

This year, more and more emphasis will be placed on small strategic teams coming from the same organization or geographical area. Two years' experience with the Laboratory has indicated many areas where more intensified work can be carried out. The Laboratory provides opportunity for action leaders, trainers, educators, and social scientists to explore, in a laboratory situation, basic concepts and skills of group growth and group leadership and membership.

The Laboratory will again be sponsored by the Division of Adult Education Services of the NEA and the Research Center for Group Dynamics of the University of Michigan, with the further cooperation of certain other leading universities.

For further information, write to Leland P. Bradford, Director, Division of Adult Education Services, NEA, 1201 Sixteenth Street, N. W., Washington 6, D. C.

WILL THE SUN GIVE MORE?

When we have used up our coal and oil, exploited our available land with intensive farming, and trebled our population, can we then call on the sun to give us still more means to satisfy our ever increasing demands for food, fuel, and power? The answer is yes! There is a long challenging road of research and development which must be followed first—and we must not get the idea that we are about to step into a new era of physical and economic abundance.

—FARRINGTON DANIELS

BOOKS AND PAMPHLETS RECEIVED

ALGEBRA, MEANING AND MASTERY, BOOK ONE, by Daniel W. Snader, *Professor of Mathematics, University of Illinois.* Cloth. Pages ix+502. 13.5×21 cm. 1949. John C. Winston Company, Winston Building, 1006–1024 Arch Street, Philadelphia 7, Pa. Price $2.20.

INTRODUCTORY RADIO, THEORY AND SERVICING, by H. J. Hicks, M.S., *Radio and Science Instructor, Central High School, St. Louis, Missouri.* Cloth. Pages viii+393. 15×23 cm. 1949. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $3.20.

ALGEBRA, FIRST COURSE, by Raleigh Schorling, *Head of Department of Mathematics, The University High School and Professor of Education, University of Michigan;* Rolland R. Smith, *Coördinator of Mathematics, Public Schools, Springfield, Massachusetts; with the Coöperation of* John R. Clark, *Teachers College, Columbia University.* Cloth. Pages ix+406. 13.5×20.5 cm. 1949. World Book Company, Yonkers 5, N. Y. Price $1.92.

MINERALS AND HOW TO STUDY THEM, by The Late Edward Salisbury Dana. Third Edition, Revised by Cornelius S. Hurlbut, Jr., Ph.D., *Associate Professor of Mineralogy, Harvard University.* Cloth. Pages x+323. 13.5×20.5 cm. 1949. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.90.

COLLEGE ALGEBRA, by Edward A. Cameron, and Edward T. Browne, *Professors of Mathematics, The University of North Carolina.* Cloth. Pages x+406. 13.5×21.5 cm. 1949. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $3.00.

THE FUNDAMENTALS OF COLLEGE CHEMISTRY, by G. Brooks Kings, *Professor of Chemistry, The State College of Washington, Pullman, Washington,* and William E. Caldwell, *Professor of Chemistry and Chemical Engineering, Oregon State College, Corvallis, Oregon.* Cloth. Pages viii+536. 14×21.5 cm. 1949. American Book Company, 88 Lexington Avenue, New York 16, N. Y. Price $4.00.

ANALYTIC GEOMETRY, by Charles H. Sisam, *Emeritus Professor of Mathematics, Colorado College.* Revised Edition. Cloth. Pages xvi+304. 13.5×19.5 cm. 1949. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $2.40.

ANALYTIC GEOMETRY, by Robin Robinson, *Professor of Mathematics, Dartmouth College.* Cloth. Pages ix+147. 15×23 cm. 1949. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $2.25.

INTERMEDIATE ALGEBRA FOR COLLEGES, by Paul R. Rider, Ph.D., *Professor of Mathematics, Washington University.* Cloth. Pages x+242. 13×20.5 cm. 1949. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.75.

NEW DIRECTIONS IN SCIENCE TEACHING, by Anita Duncan Laton, *Professor of Health and Hygiene, San Jose State College, San Jose, California,* and Samuel Ralph Powers, *Professor of Natural Sciences, Teachers College, Columbia University.* Cloth. Pages xi+164. 13.5×20.5 cm. 1949. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 18, N. Y. Price $2.50.

BASIC ELECTRICAL PRINCIPLES, by Maurice Grayle Suffern, B.S., LL.B., LL.M., *Major, Ordnance Department, Army of the United States.* Cloth. Pages ix+430. 13.5×20.5 cm. 1949. McGraw-Hill Book Company, 330 West 42nd Street, New York 18, N. Y. Price $3.20.

THE RADIO AMATEUR'S HANDBOOK, by the Headquarters Staff of the Ameri-

can Radio Relay League. Twenty-sixth Edition, 1949. Paper. 736 pages. 16.5 ×24 cm. The American Radio Relay League, West Hartford 7, Connecticut. Price $2.00 in the United States, its Possessions and Canada, $2.50 elsewhere.

RESEARCH PUBLICATIONS, ILLINOIS INSTITUTE OF TECHNOLOGY, Vol. 6, No. 3, May, 1948. Temperature Distribution in Electrical Apparatus. Two articles by Max Jakob, and Three by T. J. Higgins. Paper. 46 pages. 22×28 cm. Single copies may be obtained without charge by addressing to Graduate School, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Ill.

WORKBOOK TO ACCOMPANY EXPLORING VIOLOGY, by Ella Thea Smith. Third Edition. Paper. Pages vi+154. 19×26.5 cm. 1949. Harcourt, Brace and Company, Inc., 383 Madison Avenue, New York 17, N. Y. Price $1.20.

BITS THAT GROW BIG, by Irma E. Webber. Paper. 64 pages. 16×19.5 cm. 1949. William R. Scott, Inc., 513 Avenue of the Americas, New York 11, N. Y. Price $1.50.

ARITHMETIC TEACHING TECHNIQUES. An In-Service Survey and Study Conducted by a Committee on Arithmetic Teaching Techniques with the Cooperation of the District Superintendents, Principals, and Teachers in the Chicago Public Elementary Schools. Paper. 347 pages. 17×25 cm. 1949. Board of Education, Chicago, Ill.

HOW WELL ARE INDIAN CHILDREN EDUCATED, by Shailer Peterson, Ph.D., *University of Chicago, with a Summary Chapter by* Ralph W. Tyler and Willard W. Beatty. Paper. 182 pages. 16×25.5 cm. 1948. Department of the Interior, United States Indian Service, Haskell Institute, Lawrence, Kan.

BOOK REVIEWS

APPLIED ARCHITECTURAL ACOUSTICS, by Michael Rettinger, B.A., M.A., *Engineering Department RCA Victor Division, Radio Corporation of America, Hollywood, California.* Cloth. Pages xi+189. 13.5×21.5 cm. 1947. Chemical Publishing Company, Inc., 26 Court Street, Brooklyn 2, N. Y. Price $5.50.

A great change has taken place in the past twenty-five years in designing and building concert halls, lecture and class rooms, and all types of large public buildings where sound effects are important. Most of these changes in design have resulted from a scientific study of the reflection and absorption of sound due to the shapes of the walls and the materials of construction. This book is designed to assist the architect, the engineer, and the contractor. The first part of the book discusses the fundamental equations and geometric laws which govern acoustics, reverberation effects, how to insulate, and the various acoustic materials. The latter part of the book gives a study of sound effects in properly designed and constructed public buildings such as theaters, broadcasting studios, hospitals, churches, etc. The book is well supplied with diagrams and graphs to assist the reader, but it is a book whose special design is to help the architect and engineer, not for the general reader. There is no longer any excuse for torturing the public by putting up expensive buildings, beautiful to the eye but distressful to the ear. This book will greatly assist builders to avoid the acoustical errors of the past.

G. W. W.

READINGS IN THE PHYSICAL SCIENCES, Edited by Harlow Shapley, Helen Wright, and Samuel Rapport. Cloth. Pages xiii+501. 15×23.5 cm. 1948. Appleton-Century-Crofts, Inc., 35 West 32nd Street, New York 1, N. Y. Price $3.00.

This is another great book which should be in every science library. It consists of fifty-eight great articles, written by scientists from Copernicus to the present time. In addition there are introductions to each major section, written by the editors, and a short, well-selected bibliography following each major division. Seven pages of quotations from famous scientists follow the introduction to the first chapter. Five pages at the end of the book give a few facts about each author. The six sections of the book are on Science and Scientific Methods, Astronomy, Geology, Mathematics, Physics, and Chemistry. Paul R. Heyl and C. C. Furnas are the only authors selected as contributors to two different sciences. If you read any one of the articles you will be compelled to read more. See Galileo's "Proof that the Earth Moves," or Huggin's "Motion in the Line of Sight," or Aitken's "Driving Back the Dark," all in the section of astronomy. "The Story of a Billion Years" by Hotchkiss in the section on geology furnishes material for contemplation for a long time. No one will want to miss Madam Curie's "The Discovery of Radium," from the Bureau of Publications of Vassar College, or Heyle's "Space, Time and Einstein," reprinted from *The Atlantic Monthly*, or Robertson's "The Task of the Organic Chemist," from the University of California Press. Or if you are interested in material of a slightly different type read Whitehead's "An Introduction to Mathematics," or Smyth's "Atomic Energy for Military Purposes." "The 200-inch Telescope," an oration delivered by Sir H. Spencer Jones on May 30, 1941, is worth the price of the book—a wonderful gift book for anyone. These are only a few of the articles quoted. Each article in the book is a masterpiece. Every one is now too busy to read much of even the good material that is printed, but no one can afford to miss the articles quoted here.

G. W. W.

SOLID GEOMETRY, by James Sutherland Frame, *Professor and Head of the Mathematics Department, Michigan State College*. Cloth. Pages ix+339. 1948. McGraw-Hill Book Company, Inc. New York, New York. Price $3.50.

The title of this text is traditional, but the method of approach and much of the content varies from that found in most books. The text discusses the basic assumptions of geometry, presenting the point and distance between points as fundamental concepts and defining the line and plane in terms of these concepts. The vector concept is introduced in the first part of the book with the discussion of directed lines in space. The text emphasizes learning to visualize and to draw three-dimensional figures. Drawing is facilitated by a drawing triangle known as the trimetric ruler, which is enclosed in a pocket inside the back cover.

The book is divided into four parts as follows: I—Linear and Angular Measurement in Space, II—Solid Mensuration, III—The Sphere and Solids of Revolution, IV—Projections and Maps. Each part contains 10 chapters, the last of which is a review chapter. Each chapter closes with a list of oral questions which may be used for class discussion and a list of written exercises for assignments. Answers to odd numbered exercises are given when they are computational problems.

The material is based on plane geometry and elementary algebra, and is designed to prepare students for advanced work in mathematics and engineering. It seems to the reviewer that students who thoroughly understand the content should have an excellent background for advanced work. However, it seems that much of the material is more difficult than that in traditional texts. For example, within the space of a few pages, the cosine of an angle is defined as a projection factor, certain properties of the cosine are listed, and the cosines of angles in each of the four quadrants are used in solving problems and exercises. This is followed by a treatment of the scalar product of vectors.

Teachers looking for a challenging text in the subject as well as those looking for some variation to traditional procedure should examine this book.

G. E. HAWKINS
La Grange, Illinois

TEACHERS: You cannot afford to go through next year without the benefits derived by a regular reading of SCHOOL SCIENCE AND MATHEMATICS. *During this year, approaching our 50th anniversary, we will publish papers from some of our greatest leaders in science and mathematics education. Send your subscription now.*

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